Technology Transfer Through R&D Organizations - Industry Interaction: A Policy Analysis for a Public Research Institute in Mexico

by

LUIS A. GOMEZ UGARTE GARCIA

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Signature of the Author .....
Luis A. Gómez Ugarte García
Department of Civil and Environmental Engineering
May 13, 1994

Certified by .....
Professor Richard de Neufville
Chairman, Technology and Policy Program
Thesis Advisor

Certified by .....
Diana V. García-Martínez
Senior Liaison Officer, Industrial Liaison Program
Thesis Co-Advisor

Accepted by .....
Joseph M. Sussman
Departmental Committee on Graduate Students

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Abstract

This work analyzes the interaction between R&D organizations (RDO's) and industry. In doing so, it looks at the experiences of institutions from several countries in the establishment of programs to link both sectors; analyzes the possibilities of a particular RDO (the Mexican Institute of Water Technology - IMTA) to interact with industry; and designs a specific strategy to link this institution with the Mexican productive sector.

The analysis of previous experiences was crucial for the development of this work. It not only highlighted the problems of the interaction but most importantly, it also provided valuable insights for the establishment of efficient interaction programs. Conversations with experts deeply involved in the interaction and with vast experience in this field were particularly useful. This is the case of those interviewed at MIT, frequently regarded as a top-leading institution in the establishment of this sort of programs and at several RDO's in Mexico, as their experience is directly related to the Mexican context.

The analysis of the particular case of IMTA shows that at this point its possibilities to interact with industry are rather limited. The reasons for this assertion are that: the present structural conditions of the country make any interaction effort extremely difficult; the demand for IMTA's products and services is currently small; the judicial status of the Institute and its dependence on other public institutions constrains its capacity to interact with industry; the administrative capacity of IMTA to handle the interaction is limited; and finally, its experience with interaction is almost nil.

As a result, the benefits that IMTA may expect to derive from the interaction will be rather small, at least in the short term. However, the costs for implementing such policy will also tend to be small. Therefore, if IMTA decides to implement programs to interact with industry it should do so as a middle or long-term commitment. Viewed under this perspective it seems that the interaction has a good potential to benefit IMTA through: the generation of additional income for the Institute and its researchers; the reduction of its dependence on other institutions in the sector; and an improvement in its responsiveness to the real needs of society.

The strategy that IMTA needs to follow to interact with industry requires a reinforcement of its administrative capacity and the institutionalization of its interaction efforts. This means that IMTA will need to adopt organizational structures, policies and communication channels explicitly designed to facilitate the interaction and most importantly, to recruit personnel capable of handling efficiently such interaction.

Thesis Advisor:

Professor Richard de Neufville
Chairman, Technology and Policy Program

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List of Abbreviations

ANVAR	Agence Nationale de la Valorisation de la Recherche (France)
BTG	British Technology Group (U.K.)
CENCA	Centro de Consulta del Agua, IMTA (Mexico)
CIT	Centro para la Innovación Tecnológica, UNAM (Mexico)
CNA	Comisión Nacional del Agua, SARH (Mexico)
CONACYT	Consejo Nacional de Ciencia y Tecnología (Mexico)
CPH	Comisión del Plan Hidráulico, SRH (Mexico)
CPNH	Comisión del Plan Nacional Hidráulico, SARH (Mexico)
CRC's	Cooperative Research Centers
CT	Consultivo Técnico, IMTA (Mexico)
DC's	Developed Countries
DEPFI	División de Estudios de Posgrado de la Facultad de Ingeniería, UNAM (Mexico)
EUREKA	European Union Program to Stimulate Technological Innovation in that Continent
FES&T	Federal Expenditure in Science and Technology
GATT	General Agreement of Tariffs and Trade
GDP	Gross Domestic Product
IC's	Industrialized countries
II's	Industry Incubators
IIE	Instituto de Investigaciones Eléctricas (Mexico)
ILP's	Industrial Liaison Programs
IMF	International Monetary Fund
IMTA	Instituto Mexicano de Tecnología del Agua, CNA (Mexico)
INRS	Institute Nationale de la Recherce Scientifique (Canada)
JRDC	Japan Research Development Corporation (Japan)
LAN	Ley de Aguas Nacionales, 1992 (Mexico)
LCA	Laboratorio de Calidad del Agua, IMTA (Mexico)
LCPDST	Ley para Coordinar y Promover el Desarrollo Científico y Tecnológico (Mexico)
LDC's	Less Developed Countries
LFT	Ley Federal del Trabajo (Mexico)
MIT	Massachusetts Institute of Technology (U.S.)
NAFTA	North American Free Trade Agreement
NRDC	National Research Development Corporation (U.K.)
OECD	Organization for Economic Cooperation and Development
PHN	Plan Hidráulico Nacional, CPH (Mexico)
PRODERITH	Programa de Desarrollo Regional Integral del Trópico Húmedo, IMTA (Mexico)
PRONAR	Programa Nacional para el Aprovechamiento y Reuso de Aguas Residuales, IMTA (Mexico)
PRONEFA	Programa Nacional para el Uso Eficiente del Agua en las Ciudades e Industrias, IMTA (Mexico)
PRONEFIH	Programa Nacional para el Uso Eficiente de la Infraestructura Hidroagrícola, IMTA (Mexico)
R&D	Research and Development

RDO's	Research and Development Organizations
REPDA	Registro Público de Derechos de Agua, LAN, 1992 (Mexico)
S&T	Science and Technology
SARH	Secretaría de Agricultura y Recursos Hidráulicos (Mexico)
SHN	Sistema Hidráulico Nacional (Mexico)
SIH	Subsecretaría de Infraestructura Hidráulica, SARH (Mexico)
SINCYT	Sistema Nacional de Ciencia y Tecnología (Mexico)
SNI	Sistema Nacional de Investigadores, CONACYT (Mexico)
SRH	Secretaría de Recursos Hidráulicos (Mexico)
TLO's	Technology Licensing Offices
TM's	Technology Managers
TP's	Technology Poles (Holland)
UNAM	Universidad Nacional Autónoma de México (Mexico)
UNIKONTAKT	Kontaktstelle für Informationstransfer Universität - Industrie, at Ruhr University Bochum (Germany)
UNILINK	Industrial Liaison Program at Heriot-Watt University (U.K.)
ZIRST	Zone for the Innovation and Scientific and Technological Realization (France)

Chapter One: Introduction

The establishment of collaboration agreements between R&D organizations (e.g. universities and public research institutes) and industry is a practice that has long existed. In fact, the implementation of programs designed to link the two types of organizations can be traced back several decades, especially in the case of some industrialized countries. However, it was until the early 1980's when governments, industry and academia really directed their attention and committed themselves to study the phenomena of R&D organizations - industry interaction. Today, fifteen years later, far from being abandoned, this trend continues to be followed.

The revolution of production systems currently under way throughout the world is making these systems increasingly dependent on science and technology. As a result, firms are recognizing that more than ever, the knowledge embedded in their products and processes is a crucial element of their competitive advantage. The relevance of this vision is highlighted by the fact that there is a pronounced tendency in many industries towards the development of more competitive business environments. Moreover, the new world economic order is accentuating this effect even more because it is setting the appropriate conditions for intense rivalry and competition; especially, through the establishment of more open market economies, the emergence of regional processes of economic integration and the adoption of policies favoring the liberalization of trade and the globalization of commerce by many countries.

Although it has been observed that in developed countries (DC's), between 40 to 60% of their total R&D expenditure is undertaken directly by industry[1], it is now becoming evident that industry alone does not have enough capacity to deal with the velocity, complexity and high costs associated with the development of technological innovations indispensable to compete successfully in today's world. More and more firms are moving away from the tradition of basing their business strategies on the mere exploitation of comparative advantages (e.g. low factor costs), to adopt strategies which combine these advantages with those derived from multiple factors of competitive advantage. For example, many firms are now placing an unprecedented emphasis in aspects such as organizational learning (under a national, regional, continental or even a global scale) as one of the main dimensions of their competitive advantage. In this way, they are building their competitiveness over a much more sustainable basis. It is conditions such as these that drive industry to seek a closer collaboration with R&D organizations (RDO's). If firms are to remain competitive, they will need to look systematically for new knowledge and to be able to incorporate that knowledge into their products, manufacturing processes, organizational structures, etc.

For RDO's and, in particular, for those publicly funded, the establishment of ties with industry is becoming extremely important because many of them are being affected by considerable reductions of public expenditures in science & technology (S&T). In the U.S., for example, the reduction of public funding for military-related R&D has substantially decreased in recent years. In addition, increasing political and social pressures are being applied on RDO's to force them to perform research more responsive to civilian needs. As governments recognize the importance of technological innovation as a means to enhance the productivity and competitiveness of their national industries, they are trying to motivate RDO's to find more useful applications for their

1 Waissbluth, M., (1990), "Regulación Académica de la Vinculación", in Vinculación Universidad - Sector Productivo, BID-SECAB-CINDA, Santiago, Chile, pp. 150-163

research efforts. On the side of societal pressures, the public is demanding from them a more effective contribution to the satisfaction of societal needs as well as a deeper involvement in the search for solutions to most of the problems currently faced by their countries (e.g. environment pollution).

In some less developed countries (LDC's) like for example those in Latin America, the situation is even more critical as, in general, industry is traditionally responsible for no more than 5 to 15% of the total R&D expenditure undertaken in these countries.[2] In addition, the situation is aggravated by the fact that during the last decade, many of them were immersed (and some still are) in deep economic crisis that demanded even more stringent cuts of public funding for RDO's (particularly for universities). At the same time, societal pressures are strong and difficult to deal with because they are normally linked to the satisfaction of basic needs (health, education, provision of basic services such as energy and water supply, etc.).

Therefore, in this sense, the challenge for the entire scientific and technological community of LDC's (RDO's, industry, government, etc.) is much greater than for its counterpart in DC's. The modernization and revitalization of their domestic industries has to be achieved under adverse economic conditions, with scarce resources, and within a limited time frame as a result of pressures related to the possible entry of new competitors (particularly fostered by the adoption of policies in favor of the liberalization of trade, the reduction of the participation of the state in the productive sector, etc.).

As a result, it is no longer acceptable to nurture the interaction between RDO's and industry solely under the tradition of education and training of qualified human resources. The interaction between the two types of organizations needs to be much more

2 López, R., & Solleiro, J.L., (1992), "Promoción de la Innovación a Través de la Cooperación entre Centros de I&D y el Sector Productivo", Internal Document, CIT-UNAM, Mexico City, Mexico, pp. 101-118

profound and to involve a wider spectrum of activities if it is to really contribute to economic development.

The purpose of this work is to study the interaction between RDO's and industry; to analyze the experiences of several organizations in developed and developing countries regarding the management of interactions of this sort; and to apply the insights gained throughout the process to develop a strategy to improve the ties between a particular public research institute (the Mexican Institute of Water Technology) and the Mexican industry.

In order to do so, extensive interviews were performed at several organizations inside and outside Mexico that have been remarkably successful in the implementation of cooperation programs with industry. Particularly relevant for the development of this work were those performed at the Massachusetts Institute of Technology (MIT), in the U.S. and those at the Institute of Electrical Research (IIE) and the Technological Innovation Center (CIT), in Mexico. In the case of MIT, the insights gained from the interviews were particularly enlightening because they came from professionals working at one of the world's pioneering institutions in the establishment of programs of this sort and having vast knowledge and experience in issues related to the interaction process. In the case of the two institutions in Mexico, their experiences were especially valuable because they came from institutions that have succeeded in the establishment of interaction programs within the specific Mexican context. In addition, several interviews were performed at the Mexican Institute of Water Technology (IMTA) to get acquainted with its objectives, organizational structure, policies, procedures, personnel and organizational culture because the development of an adequate strategy for the interaction of the institute with industry necessarily requires first a good understanding of all these aspects.

Chapter Two presents an overview of the most important factors that need to be considered to analyze the interaction between RDO's and industry. The Chapter includes first, a discussion of the main motivations and barriers that usually drive or inhibit both parties to seek collaboration with each other. Next, it describes some of the most common mechanisms used for the interaction as well as some of the typical organizational structures usually adopted to promote, guide, support and/or manage these relations. Finally, the Chapter describes certain requirements that may be instrumental for the successful implementation of linkage programs of the sort under study.

Chapter Three consists of a description of the process of RDO's - industry interaction for the particular case of Mexico. It includes a description of the main industrial development strategy followed by the country during the last decades as well as an overview of the political, technical, economic and social environment currently influencing the interaction process in the country. Similarly, the Chapter also presents an overview of those procedural and motivational factors that have an important impact on RDO's - industry interaction in Mexico. Finally, it concludes with the presentation of some examples of programs of this sort that have been successfully implemented in the country.

Chapter Four consists of a description of the institution for which the linkage strategy is being developed in this work (the Mexican Institute of Water Technology - IMTA). This description includes, among others, the objectives, organizational structure, activities, programs, areas of research and regulations of the institute as well as it human, financial and material resources.

Chapter Five presents a policy analysis of IMTA's decision to seek a more active collaboration with the productive sector. The chapter looks at the particular context and circumstances that gave rise to the institute's desire to collaborate with industry as well as to the characteristics and perceptions of the policy-makers that will need to formulate such policy. In addition the chapter analyzes the particular concerns of the institute's policy makers as a means to explain the content of the resulting policy. And finally, it concludes with an assessment of the particular resources that will be needed to implement the policy.

Chapter Six describes the linkage strategy that the institute may follow. This includes, among others, the definition of objectives and goals for seeking the interaction; an assessment of the internal and external conditions that might influence the establishment of relationships with industry; an assessment of the resources and capabilities of IMTA; the identification of potential areas of linkage; the selection of specific mechanisms for the interaction; the design of policies and norms to regulate the relationships with industry; and finally, the design of formal and informal organizational arrangements to manage the linkage.

Finally, Chapter Seven presents some conclusions that can be drawn from this work and includes a series of recommendations that professionals may follow when facing similar challenges.

Chapter Two: Technology Transfer through R&D Organizations - Industry Interaction

II.1 Introduction

The transfer of technology from RDO's to the productive sector is a phenomenon that has long existed. However, what has changed throughout the years is the nature of the technology transferred. If one considers the term "technology" as encompassing knowledge, expertise or know-how and inventions or discoveries, it is possible to affirm that universities and other RDO's have traditionally focused in the transfer of knowledge (mainly through education and publication of papers) and have paid less attention to the transfer of expertise and inventions to the productive sector. This condition is only a reflex of the greater involvement of RDO's in basic rather than in applied research. However, as a result of current changes in the economic, political, technical and social environment surrounding their activities many RDO's are now starting to be more concerned with the transfer of technology in the form of know-how and inventions.

According to Mackenzie and Rhys, the level of technology transfer from RDO's to industry will depend upon two factors: a) the extent to which RDO-generated technology is relevant to industry's and government's needs and; b) the ease with which technology can flow between RDO's and the external environment.[3]

Obviously then, the accomplishment of an effective technology transfer will require substantial interaction between RDO's and industry. In order to do so, it is absolutely essential to instrument appropriate links and communication channels to facilitate such

3 Mackenzie, I. & Rhys, R. J., (1985), "Universities and Industry - New Opportunities from Collaboration with Universities and Polytechnics", The Economist Intelligence Unit, The Economist Publications Ltd., London, U.K.

interaction. The relevance of this statement must be stressed because it has been observed that the success of linkage program will largely depend on the ability of individuals from both organizations to establish personal relationships as they seem to be one of the most efficient channels for technology transfer (Rhys, 1985).

From the presentation made in the introductory Chapter of this work it seem that important conditions are already set in place to foster a more active cooperation between RDO's and industry. However, in reality this process is not so simple. The phenomenon of interaction between the two sectors is very complex. Multiple factors can directly or indirectly influence the process. Not only are there differences per se in the perceptions of individuals from both parties towards the interaction but there are also many institutional policies and practices that influence and shape their attitudes. Moreover, many factors in the environment surrounding RDO's and industry may also affect the process. As a result, it is common to observe for example, how differences in opinions or administrative procedures can destroy an otherwise fruitful relation if not properly handled. The main problem is that it is not easy to alter the cultural, social and economic differences between the two sectors. Therefore, what is needed is to design appropriate mechanisms, policies and organizational structures to reduce potential tensions and to adequately manage the relationship.

II.2 Motivations and Barriers for the Interaction

The first step required to analyze the phenomenon of RDO's - Industry interaction is to understand what are the main motivations that drive each side to seek collaboration with the other.

II.2.1 Motivations for Interaction

In an extensive study of the experiences of 39 universities and 56 companies in the US, Peters & Fusfeld identified the principal factors motivating the interaction between universities and industry. The results of their study, which was based on personal interviews made to professionals working at these organizations is summarized in Table II.2.1.1 (listed in decreasing order with respect to the frequency with which each factor was cited among the persons interviewed).[4]

Even though most of the factors cited in Table II.2.1.1 are self explanatory, it is worth making an additional comment on some of them. Starting with the factors motivating universities, it is important to point out the following: First, from the responses obtained it was observed that the motivating factor most frequently cited was, not surprisingly, the need of universities to diversify their funding sources. However, except from the last motivation (which was the less frequently cited), the rest of them were more or less cited with the same frequency. Second, the beliefs of many university researchers that industry money requires less "red tape" than government money is an important motivating factor. Indeed, it is frequent to observe how researchers try to spend as little time as possible in administrative functions to dedicate instead this time to the research itself. And third, only a small percentage of respondents cited special government programs to fund cooperative research as motivating factors. This is a somewhat surprising result as these funds are frequently adequate for the financial needs of research projects; its low importance can probably be attributed to the unawareness of many researchers and/or RDO's of the existence of these programs.

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4 Peters, L. S., & Fusfeld, H. I., (1982), "Current U.S. University/Industry Research Connections", in University Industry Research Relationships, National Science Foundation, U.S. Government Printing Office, Washington, D.C., U.S.

Table II.2.1.1 Factors Motivating University - Industry Interaction

UNIVERSITY	INDUSTRY
• Industry provides a new source of money; this helps diversify the university's funding base	• To obtain access to manpower (students and professors)
• Industrially sponsored research provides students exposure to real research problems	• To obtain a window on science and technology (technology scouting)
• To provide better training for the increasing number of graduates going into industry	• To seek general support of technical excellence
• Industrial money involves less red tape than government money and reporting requirements are not as time consuming	• To gain access to university's facilities • To obtain prestige or enhance the company's image
• Industrially sponsored research provides an opportunity to work in an intellectually challenging research program which may or may not be of immediate importance to society	• To be good local citizens or enhance the company's image • To make use of an economic resource
• To gain access to company's research facilities and equipment	• To solve a problem or get specific information unavailable elsewhere
• To obtain government funds available to support applied research efforts involving certain kinds of university - industry collaborations	

Source: Peters, L. S., & Fusfeld, H. I., (1982), op. cit.

With regard to industry it is necessary to point out that by far the most frequently cited motivation was the access to manpower (75% of respondents), especially in terms of the recruitment of graduate students. Technological scouting was the second most important motivating factor (for approximately half of the respondents). It seems that this factor is

particularly important for firms participating in industries in which the rate of technological innovation is high and in which the life cycles of products are frequently being shortened as a result of intense competition (e.g. microelectronics). Also, the desire of firms to obtain prestige through collaboration with universities proved to be a more important factor than one might initially assume. Not only do firms wish to collaborate with the best expertise but they also want others to identify them as collaborators of prestigious RDO's. Finally, with regard to the development of new products, it is important to point out that the relative low frequency with which this factor was cited reflects the fact that industry rarely supports university research as a planned stage of product development.

Other authors have found it useful to classify these motivating factors according to certain criteria (e.g. importance, nature, etc.). From all of them, the one presented by Solleiro (1990)[5] and López et al. (1992)[6] may be particularly appropriate for the purpose of this work. According to them, the main factors motivating universities and industries to collaborate with each other can be classified as structural, institutional and individual. "The structural conditions related to university-industry collaboration are those determinants deriving from economic, political and technological spheres which have a wide influence over the whole range of activities in that country but that exert especial impact on the institutions and individuals involved in the interaction, motivating or preventing cooperation" (López et. al., 1992). Typical examples include a decline in government expenditure in science and technology matters (e.g. reduction of public funding for R&D projects), trade and industrial policies, economic conditions, etc. The second set of variables derive from the particular characteristics of the institutions and organizations involved in the interaction process (e.g. organizational structures, internal

5 Solleiro, J. L., (1990), "Gestión de la Vinculación Universidad-Sector Productivo"., in Vinculación Universidad-Sector Productivo, BID-SECAB-CINDA, Santiago, Chile, pp. 167-192

6 López, R., et. al., (1992), "Motivations and Obstacles to University Industry Cooperation (UIC). A Mexican Case", Internal Document, CIT-UNAM, Mexico City, Mexico

policies, regulations, procedures, etc.). Finally, the individual factors motivating the interaction refer to those aspects that influence particular participants in the process individually. Examples of this sort might include, recognition from the academic community, personal income, professional satisfaction, etc. Table II.2.1.2 presents the principal motivating factors classified according to these criteria.

II.2.2 Barriers for Interaction

In 1984, the Canadian Corporate-Higher Education Forum published the results from a large research project intended to study the phenomena of RDO's - Industry interaction in that country.[7] Among their most important findings, this work identified the barriers for the interaction most frequently encountered in Canada. Table II.2.2.1 presents a summary of their findings.

As seen in Table II.2.2.1, three basic barriers can be distinguished: First, the nature of the research (basic vs. applied) often creates conflicts between the two parties. On the one hand, RDO's are usually interested in pursuing knowledge at its frontiers. As a result the goals of their research projects tend to be not clearly defined and their research efforts to be seen as rather long-term commitments because of the large uncertainties involved (basic research). In contrast, industry considers that research should be much more focused, with its results clearly impacting products or processes and involving short-term commitments (applied research).

Second, industry's demand to maintain the confidentiality of results of the projects they fund frequently represents a controversial issue because RDO's have the responsibility of disseminating knowledge throughout society. The adoption of this position by industry

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[7] Cyr, R., et al., (1985), "Spending Smarter: Corporate-University Cooperation in Research and Development", Corporate-Higher Education Forum, Les Editions Marquis Ltée, Montreal, Canada

Table II.2.1.2 Classification of Factors Motivating the Collaboration Between Universities and Industry

TYPE	UNIVERSITIES	INDUSTRY
Structural	• Reduction of public funds to support R&D efforts • Skyrocketing capital costs necessary both for maintaining up-to-date facilities and for advancing state-of-the-art research	• Need to increase their knowledge base to maintain or enhance their competitiveness in highly dynamic business environments. • Difficulties in access to certain technologies as a result of high acquisition costs, tariffs, etc.
Institutional	• Lack of laboratory equipment or financial resources for research projects • Increased flexibility from diversification of funding sources • Increased institutional prestige and reputation • Intellectual stimulus to enhance the quality of research • To respond to growing social pressure to contribute to the solution of real problems from society • To Contribute to the diffusion of knowledge • To keep researchers updated and/or to corroborate knowledge • To expose researchers to industrial environments • To enhance the quality of education and training for students	• Lack of human / financial resources to install in-house R&D labs • Loss of technical competitiveness due to increasing technological complexity • Recruitment of personnel • To enhance public image and reputation • It is easier and cheaper to contract university research than to obtain a license to exploit certain technologies • Possibility of obtaining indirect financial benefits from cooperation agreements (e.g. tax exemptions) • Monitoring of technological frontiers (technology scouting) • Opening of new technological windows • Development and application of new technologies • Improved training and motivation for future employees
Individual	• Possibility of increasing their own knowledge by confronting challenging problems or by contacting other researchers whom they might otherwise not encounter professionally • Possibility of increasing personal income • Collaboration with industry contributes to keep researchers updated and to increase their prestige • Satisfaction derived from the contribution of the researcher to accomplish the social function of the university • Elimination of stereotype of researchers as living in an "ivory tower" and lacking experience in the solution of industry needs	• Possibility of researchers to remain abreast of state-of-the-art knowledge and technologies. • Improved understanding of business in the academic world

Source: Adapted partially from López et. al., (1992), op. cit.

Table II.2.2.1 Barriers Inhibiting R&D Organizations - Industry Interaction

TYPE	BARRIER
Basic	• Nature of research • Publication and confidentiality of results • Project management
Procedural	• Inadequate marketing • Contract complexity • Interdisciplinary walls • Geopolitics
Motivational	• Lack of confidence / trust • Not-invented-here syndrome • Doubts regarding the usefulness of research • Availability of true talent

Source: Adapted from Cyr et. al., (1985), op. cit.

derives from the beliefs of many industrialists that it is not justifiable to fund RDO's research if the fruits of that research can be freely appropriated by other parties (particularly by competitors). After all, they are the ones devoting the resources and assuming the financial risks involved in the effort. On the side of RDO's both the institutions and its personnel constantly need to publish research results to enhance their reputation. In the case of researchers, this issue is particularly relevant because it is a well established practice in many RDO's and especially in the academic environment to evaluate the quality of their research and/or productivity in terms of the number and quality of the articles they publish per year. This is extremely important because, at the end, this evaluation is normally tied with awards, monetary incentives, promotions, etc.

The third structural barrier frequently encountered is related to controversies regarding project management. It seems to be easy for both parties to fall into a continuous power

struggle to control research projects. On the one hand, industry tries to exercise a tight control over project costs and schedules as they have a tendency to believe that researchers are informal when it comes to meeting deadlines. On the other, RDO's try to insure that researchers are provided with enough latitude and flexibility to adjust schedules and shift funds among different budget categories to respond promptly to project requirements. For RDO's, this is an extremely important factor because it is very difficult for them to prepare detailed programs due to the uncertainties inherent to research.

In terms of the procedural barriers, the following four were identified: a) inadequate marketing by universities; b) contract complexity; c) geopolitics; and d) interdisciplinary walls. First, many firms claim that one of the main barriers for the interaction is the inadequate promotion of RDO's capabilities and services (technical expertise, areas of research, projects under execution, available facilities, etc.). Second, it is frequent to find lack of expertise in the negotiation of contracts (especially in RDO's). Researchers tend to feel uncomfortable dealing with long and complex contracts which they fail to understand entirely. Therefore, the use of standard contracts might be advisable so that negotiations will only need to deal with certain deviations derived from peculiarities of the project or from the specific requirements of each party. Third, it has been observed that projects which require the integration of multidisciplinary teams are difficult to establish and manage by universities because of their lack of experience working with this kind of teams. And finally, the psychological and physical distance between the two sectors can also be important barriers. Psychological barriers are represented by differences in culture and values that are frequently difficult to overcome while physical distance is a barrier that is beginning to loose importance with the development of modern communication systems (although many firms still clearly have more intense patterns of collaboration with RDO's located close to them).

Finally, at the motivational level, the following four barriers have been identified in the literature: a) lack of confidence/trust; b) not-invented-here syndrome; c) existence of doubts regarding the usefulness of the interaction; and d) availability of talent. The lack of confidence and/or trust is a phenomenon that might exist in either party or in both. On the part of industry there seems to be sometimes a perception that RDO's only look at industry as "gold mines" and that they have a tendency to divert the funds provided by industry to other areas out of the immediate scope of the project for which these funds were provided. On the side of RDO's, many researchers see the goals of industry as merely mercantile and believe that the establishment of close relations between the two sectors will only lead to a loss of the independence and integrity of RDO's.

The not-invented-here syndrome is a phenomenon that can also negatively influence the relationship through both parties. Many researchers (both in industry and in RDO's) sometimes adopt negative attitudes towards ideas, results, general knowledge or even technologies originated or developed in other organizations, institutions or sectors. Somehow they seem to believe that they are less virtuous, valid or important just because they were not developed in-house. This attitudes represent a barrier that is difficult to overcome because in many occasions neither the individual nor the organizations are really aware of their existence or they simply fail to give it the necessary importance. This rejection attitudes does not necessarily have to be taken as ill-intentioned because it is perfectly logical that researchers feel more comfortable working with the procedures, methodologies or technologies with which they are more familiar (and which most likely, will correspond precisely to those developed inside their own organizations).

Many firms tend to express doubts regarding the usefulness of university expertise because they simply cannot envision university researchers with similar or more

experience than their own in the solution of specific industry problems. Also, the scarcity of talent has sometimes been reported as problematic because many researchers use the pretext of lack of time to excuse themselves from not accepting to participate in research projects that are not intellectually nor financially interesting to them (Solleiro, 1990).

In order to provide some coherence with the criteria used to classify the main motivations for the interaction, López, et al, (1992) followed a similar rationale to classify the main barriers inhibiting the interaction. (see Table II.2.2.2)

II.3 Mechanisms for the interaction

The exchange of knowledge, resources and technology between RDO's and industry is a broad phenomenon that can adopt diverse modalities ranging from formal to relatively informal (López, et al., 1992). The mechanisms used for the transfer simply represent working relationships through which the two sectors interact with each other and which ultimately are dependent on the particular communication networks set in place by each organization to manage the interaction (López et. al., 1992). Table II.3.1 shows some of the mechanisms for the interaction identified from the literature related to this subject.

II.4 Organizational Structures to Promote/Manage RDO's - Industry Interaction

As mentioned in the preceding section, the mechanisms for RDO's - Industry interaction can range from formal to relatively informal. The organizational structures established to promote, guide, facilitate or manage these mechanisms should be designed considering these characteristic to improve their chances for success. They should be consistent with existing communication channels or otherwise these need to be adapted or created.

There is a wide variety of organizational arrangements that can be set in place to manage the interaction. However, the following are the ones most frequently encountered:

Table II.2.2.2 Classification of Barriers Inhibiting the Collaboration Between R&D Organizations and Industry

TYPE	BARRIER
Structural	• lack of financial resources and entrepreneurial mentality (disposition to assume risks) • cultural gap, lack of communication, incompatibilities, mutual distrust of capacity of human resources and of institutional responsiveness to objectives • instability of public universities [8]
Institutional	• Excess of RDO's bureaucracy • Disagreements concerning research costs, confidentiality and industrial property rights • technological gap between RDO's and firms; lack of participation by firms in the early stages of project definition • insufficient recognition for applied research
Individual	• Not-Invented-Here Syndrome • Belief that academic researchers live in an "ivory-tower" • Belief that cooperative research makes RDO's dependent on industry, deviating its objectives and mission and/or generating internal conflicts of interest

Source: Adapted from López, et al., (1992), op. cit.

[8] This is an issue that seems to be particularly relevant, at least in the case of several LDC's. The political and social instability of public universities seem to have a negative influence in the perception of many industrialists towards the interaction because it is frequently seen as increasing the risks associated with the cooperative efforts.

Table II.3.1 Mechanisms for R&D Organizations - Industry Interaction

- Access to specialized facilities
- Awards for students, professors and researchers
- Conferences, colloquia, symposia and workshops
- Continuing education
- Cooperative education
- Corporate financial support for basic research
- Corporate financial support for colleges and universities
- Corporate financial support for students (scholarships, fellowships)
- Corporate financial support for the establishment of special courses and/or seminars
- Corporate recruiting of students
- Joint product or process development (cooperative research)
- Personnel exchange (internships and sabbaticals)
- Provision of specialized services (e.g. information searches)
- Technical assistance
- Technology transfer
- Training programs
- Volunteer programs, trusteeships and directorships

Source: Adapted partially from Solleiro J.L., (1990), op. cit.

II.4.1 National Systems for the Exploitation of Technology Developed at RDO's

Several governments have made attempts to promote the exploitation of technologies developed at universities and other public research institutes through the establishment of

special agencies, organizations or other public bodies to facilitate the licensing of their inventions and commercialization of their technology.

The French Agence Nationale de Valorisation de la Recherche (ANVAR) was created in 1968 by the French National Scientific Research Council to provide support to inventors and to facilitate the transfer of scientific and technological knowledge from RDO's to industry (Mackenzie & Rhys, 1985). Some of the most important tasks of this agency include the valuation of technologies and the performance of marketing studies to determine the feasibility of successful commercialization of specific technologies. In the cases in which these studies show promising results the agency finances up to 50% of the incurred costs (which are paid back only if such projects are indeed successfully commercialized). In the event that patents are obtained, ANVAR maintains the property rights and licenses the technology in exchange for a royalty payment. In addition ANVAR provides funds for the construction of laboratories in other countries as well as for the establishment of cooperative research centers with industry. Finally, ANVAR is the French Agency representing France in project EUREKA, the European Community program to stimulate technological innovation in Europe.[9]

The British National Research Development Corporation (NRDC) of the UK (now British Technology Group - BTG) was founded back in 1948 to exploit inventions derived from government funded research.[10] The tasks of the agency are to examine the output of research centers to look for ideas that are patentable, to protect the interests of the center and to try to obtain some revenue from the use and exploitation of the patent. Therefore, BTG actually works as an intermediary that had, until 1983 (after this date this

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9 Centro para la Innovación Tecnológica, (October, 1992), "Rhone Alpes: La Región de Todas las Industrias", in Integración Tecnológica, CIT, Unidad de Difusión UNAM, Mexico City, Mexico, pp. 29-30

10 Organization for Economic Cooperation and Development, (1984), "Industry and University - New Forms of Co-operation and Communication", OECD Publications, Paris, France

requirement was eliminated), first right for the ownership and exploitation of all the inventions derived from government sponsored research (Mackenzie & Rhys, 1985).

In Japan, the federal government created the Japan Research Development Corporation (JRDC) to promote the execution of development projects by contract and technology licensing activities. In the first case, JRDC organizes proposals for development projects and selects the company to carry out the work. If the project succeeds the company is allowed to commercialize the new technology under a new contract in which the firm agrees to reimburse JRDC the total project costs and to pay them a royalty fee. In the second case, the main role of JRDC is to take appropriate measures to facilitate the licensing of patents held by publicly funded RDO's (OECD, 1984).

In general organizations like the ones previously described have been relatively successful.[11] However, some researchers in this theme believe that they are highly risk averse (Solleiro, 1990; Mackenzie & Rhys, 1985), that they involve long and tedious bureaucratic procedures (Solleiro, 1990), that they have discouraged the search and establishment of alternative commercialization channels by universities (Mackenzie & Rhys, 1985) and that some of their policies (e.g. denial to grant exclusive licenses by BTG) have discouraged the involvement of industry (Mackenzie & Rhys, 1985).

II.4.2 Industrial Liaison Programs

The establishment of industrial liaison programs (ILP's) is primarily intended to provide the appropriate communication channels to facilitate the interaction between RDO's and industry. However, it is important to point out that these formal communication channels are not so relevant per se but as means to develop more informal relationships

11 For example, in the case of the UK in the period comprehended between 1952 and 1985, from 20,000 inventions, 7000 were commercialized with the help of BTG (then NRDC), which obtained revenues from over 1000 of them (Mackenzie, I., (1985), op. cit.)

vital for technology transfer and successful innovation. Although the services offered through these programs have considerably expanded since the first versions of them were established, broadly speaking they are mainly concerned with: a) directing industrialists seeking help to the appropriate RDO's expertise; and b) with the promotion of RDO's activities (primarily to attract industrial support for R&D).

Although there are numerous examples of liaison programs that could be cited, it is important to mention that these types of programs usually vary widely in their objectives, legal constitution, administrative structures, operational procedures and services provided. In the UK, there is for example the case of the industrial liaison program founded by the Heriot-Watt University (UNILINK), to provide a bridge between the University and the Edinburgh industry (Mackenzie & Rhys, 1985). In Germany, "UNIKONTAKT" is a liaison program operated jointly by Bochum and Dortmund Universities primarily intended to direct industrialists from the Ruhr region to appropriate universities' expertise (OECD, 1984). In Holland, ILP's (termed "Transfer Points") share similar purposes but are organized under a regional basis. This is the case for example, of the Transfer Point (TP) established by the Technical University at Twente (OECD, 1984). The experience of the TP's is especially interesting because, as distinct from many other industrial liaison programs, they are explicitly designed to promote linkages with small and medium-size firms rather than with large corporations.

However, the most successful ILP's have been established in the US rather than in Europe. This is the case of those established at the Massachusetts Institute of Technology (MIT) and at the University of Stanford (Peters & Fusfeld, 1982). In fact, these programs have not only succeeded in the accomplishment of their liaison objectives but they are also financially sane.[12] In both cases companies get enrolled in the program through the

12 Just in one year (1991), the revenues obtained by MIT's Industrial Liaison Program exceeded $8 million, of which, approximately $3 million were granted to MIT's operational budget. Source: Araoz,

payment of a membership fee.[13] In return, the ILP's offer them a series of customized services to maintain them informed of the latest developments in science and technology. For example, Table III.4.2.1 shows some of the services offered by MIT's Industrial Liaison Program to its members.[14]

Table II.4.2.1 Services Provided by MIT's Industrial Liaison Program

• Meetings with faculty and staff
• Visits of faculty and staff to member companies
• Symposia, seminars, conferences, workshops, etc.
• Publications of current research, patent activity at MIT, activities on campus, recent company spin-offs, new faculty appointments, information of out coming students (resume books), etc.
• Linkage to MIT resources (researchers and fields of research)
• Offering of special courses in specific areas of interest to its members

The Stanford's Industrial Affiliates Program (IAP) differs from MIT's Industrial Liaison Program in that there is a separate program for each department (Mackenzie & Rhys, 1985). Although Stanford's IAP is much more focused than MIT's Industrial Liaison Program, they both share the similar broad communication goals. However, the program at Stanford places more emphasis in the promotion of consulting activities by faculty as well on the establishment of continuing education programs than that of MIT (Mackenzie & Rhys).

A., (1993), "How MIT Interacts with Industry: Some Teachings for Latin America", Unpublished Paper, MIT, Cambridge, Massachusetts, U.S.

13 In contrast, most ILP established in Europe obtain their financial resources through the appropriation of a percentage of any contract channeled through them.

14 Massachusetts Institute of Technology, (1993), "The MIT Industrial Liaison Program: A Guide to Members", Internal Document, MIT-Industrial Liaison Program, Cambridge, Massachusetts, U.S.

II.4.3 Technology Licensing Offices

Technology licensing offices (TLO's) are specialized units integrated into many RDO's to facilitate the transfer of technology from RDO's to industry through the licensing of patents and other forms of intellectual property. In general, the responsibilities of TLO's can be summarized as: a) the review of patent disclosures; b) the pursue of patent applications for promising technology developments; and c) the negotiation of patent and copyright licenses.

Again, two of the best examples of TLO's that have been successful are found at MIT and Stanford (together with the University of Wisconsin). Each day MIT's Technology Licensing Office receives one or two inventions, files about three patents applications per week and ends up licensing over 90 per year (Araoz, 1991). Only in 1988, the 92 licensing agreements signed by the office generated more than $6.2 million in royalty payments for the institute.[15] In the case of Stanford, its TLO licensed in the same year only 75 patents, but obtained an income of approximately $9.2 million in royalty payments (Preston, 1988).

According to Dr. Preston, director of MIT's Technology Licensing Office, this office has mainly four goals: a) to bring about the efficient transfer of technology as a way of making technology available to the public; b) to manage conflicts of interest that are inherent in faculty-industry interactions; c) to make money for the institute and its researchers; and d) to generate good will both internally with MIT staff and externally with the licensees. To accomplish these and similar goals it is essential for offices of this sort to formulate clear licensing policies and to define a transfer philosophy (patent ownership, licensing, royalty payments, etc.). However, it is recommended to allow some flexibility to provide enough latitude to negotiate with industry (Preston, 1988).

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[15] Preston, J. T., "The Role of the University Licensing Office in Transferring Intellectual Property", Internal Document, MIT-Technology Licensing Office, Cambridge, Massachusetts, U.S.

Finally, it is important to mention that besides the functions previously described, many TLO's have an active participation in the promotion of start-up companies (spin-offs) based on technologies developed at RDO's. For example, in the case of MIT, only in four years (1984-1988), its TLO got involved in the creation of more than 40 spin-offs (Preston, 1988). The principal role of TLO's in this case is to help locate private sector funds to support and develop the new companies. However, it is important to note that MIT's Technology Licensing Office philosophy of sharing the risk with the licensees starting the new ventures, greatly enhances their chances for success (as the TLO allows for example, the deferral of cash fees, the waiver of fee payments or the exchange of fee payment for equity without an initial licensing fee).

II.4.4 Firms Founded by RDO's to Commercialize their Technology

The establishment of these organizations is a result of the initiative of several RDO's that have recognized that institutional barriers such as the excessive bureaucratic procedures of many RDO's can be surmounted through the adoption of organizational structures more familiar to industry. Vuman Ltd., a firm created by the University of Manchester in the UK, represents an example of this sort (OECD, 1984). The company was founded by the University to "select likely inventions and to assist university scientists in developing their ideas to a point where they might be commercialized either by themselves or perhaps in conjunction with another firm" (OECD, 1984). In addition, Vuman LTD. provides financial and managerial support to academics desiring to commercialize ideas.

Although firms like Vuman have in general been successful, authors like Solleiro (1990) point out that they have a tendency to be to selective in the technologies they support and that they normally assume a reactive rather than a proactive attitude towards the identification of promising technologies.

II.4.5 Technology Brokers

Technology brokers are independent firms specialized in the management and commercialization of technology. Although this type of organizations play a role similar to firms like those described in the previous section (such as Vuman Ltd.) their characteristic of being independent from both industry and RDO's frequently causes a lack of trust and confidence from both parties to contract their services. This condition, coupled with the uncertainties and high risks involved in the commercialization of sophisticated technologies which frequently require their services has made it difficult for them to succeed in their efforts.[16] As an example, Davis (1985) reports that Patents Inc., a U.S. technology broker lost over $1.1 million in 1984.

II.4.6 Technological Innovation Centers

Although many technological innovation centers play similar roles and offer similar services as some of the other organizational structures described in this work, its principal distinction is their dedication to the study of the process of technological innovation. The reason for this attitude is that it is believed that a better comprehension of this process can significantly contribute to stimulate innovation, to ease technology transfer and, in general, to strengthen the ties between RDO's and industry. For these reasons, much of the efforts of these organizations are centered around the education of professionals in areas related with technology management and technological innovation. In particular, many of the courses offered at these centers are intended to prepare future entrepreneurs.

In general technological innovation centers are considered to be adequate means to achieve a good RDO's - Industry interaction. In particular, the experiences of several of these centers established in the US is quite encouraging (see Peters and Fusfeld, 1982).

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[16] Davis, B., (October, 1985), "Technology Brokers Meet Limited Success", in High Technology, Technology Pub. Co., Boston, Massachusetts, U.S., pp. 66

For this reason, other DC's like Canada and Ireland as well as LDC's like Mexico have been following their steps in recent years.

II.4.7 R&D Consortia and Cooperative Research Centers

It is becoming increasingly popular for groups of companies to get together and sponsor research through the establishment of a consortium. This trend has been particularly observed in high tech industries in which the costs of performing R&D alone are becoming prohibitive (e.g. biotechnology). It is important to note that because of their nature, R&D consortia are usually established to sponsor basic rather than applied research. As a result of this characteristic disputes over intellectual property are almost never an issue. A traditional example of an R&D consortia is the Council for Chemical Research, established in the US in 1982 and having a partnership of more than 37 firms and 128 universities (Peters & Fusfeld, 1982). More recently, universities like MIT, represent examples of institutions that are aggressively pursuing the establishment of these types of cooperation agreements.[17]

A more durable and longer-term commitment for cooperative research efforts between RDO's and industry is the establishment of Cooperative Research Centers (CRC's). As in the case of consortia, CRC's are mainly focused on basic research. This characteristic allows the centers to obtain support from firms immersed in a wide variety of industries because their research fields frequently cut across the interests of several industries. In the US the initiative for the establishment of these centers came from the National Science Foundation (NSF), which during the 1970's and 1980's: a) provided seed money to fund the centers; b) promoted an increasing involvement and acceptance of financial compromises by industry in the centers; and c) supported the centers during their first years of operation (hopefully no more than five) before industry assumed full financial

[17] MIT constantly hosts approximately 70 consortia in a wide variety of research fields.

responsibility for their operation (Peters & Fusfeld, 1982). As a consequence, some of the most successful CRC's have been established in the US (e.g. MIT Polymer Center). However, there are also interesting experiences in other developed countries like Canada (OECD, 1984), with the establishment of the Institute Nationale de la Recherche Scientifique (INRS), sponsored jointly by the Canadian Government and Bell Northern Research (a wing of Bell and Northern Telecom).

The success of CRC's can be attributed to several factors. First, the mere concept of the center provides more focus (as they address specific needs and concerns) to the research and this might facilitate cooperation with industry; second, their typical organizational structure (more familiar to firms) is viewed, in general, as providing a more convenient interface with industry; and third, their condition of being "generic research centers", allows them to diversify their funding sources (government, RDO's, multiple industries, etc.).

II.4.8 Industry Incubators

Industry incubators (II's) are organizations established to promote the creation of technology-based firms. These incubators are usually founded by universities and other RDO's and are constructed in land developments near these organizations (although quite frequently the initiatives for their creation come from federal or state governments). In order to stimulate the creation of new firms, these incubators offer facilities and services to groups of firms which share them to reduce their initial operation costs. Among the facilities and services frequently provided by II's the following are the most important: physical space, laboratory services, office equipment, managerial and legal support, accounting services, means to get financial support, access to information systems (libraries, databases, computer networks, etc.) and human resources (students and

researchers). Although the time allowed for firms to remain in the incubator varies, a period of 3 to 5 years seems to be quite common (Solleiro, 1990).

The creation of II's is mainly intended to protect newly established firms in the stage in which they are most vulnerable. This is so because it is in this stage when firms have to make large disbursements to pay for installation costs and also because the uncertainties associated with the actual demand for their products and their lack of experience makes them especially susceptible to drawbacks. It is believed that through the reduction of initial operating costs, the facilitation in access to funding sources and the offering of specialized services to these firms, II's can significantly increase the possibilities of these firms to successfully commercialize their products or processes.

An interesting aspect of industry incubators is the criteria that is beginning to be popular to select the firms allowed to be incubated. For example, in some less industrialized countries like Mexico, these firms should be: a) environmentally sane and moderate consumers of energy and other natural resources such as water; b) producers of high value-added products; c) very promising in terms of profitability; d) capable of developing international markets for their products; e) employers of specialized labor; and f) capable of creating new jobs.[18]

II's have demonstrated to be very effective to promote the creation of new technology-based firms, to facilitate the transfer of technology from RDO's to industry and to strengthen the ties between the two sectors (especially in industrialized countries like the US). However, in LDC's, the creation and operation of II's has not been as successful.

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18 Talavera, A., (1991), "Nuevos Instrumentos de Desarrollo Tecnológico en México: Las Incubadoras de Empresas de Base Tecnológica (Contexto y Diagnóstico)", Memorias del IV Seminario Latinoamericano de Gestión Tecnológica, Caracas, Venezuela, pp. 337-346

However, countries like Mexico and Venezuela still have plans for the establishment of several incubators.

II.4.9 Technology Parks

Although some authors (like Escorsa, 1991) believe that in order to analyze the experiences of technology parks it is necessary to differentiate them from "science parks" (UK), "research parks", "technopolis" and "technopols" (France), for the purpose of this work they will be treated indistinctively.[19] In general, technology parks can be defined as land developments that are normally constructed near major universities or other prestigious research institutions to: a) attract firms or corporations which are traditionally involved in R&D activities; and b) to provide the ground for the creation of new high tech ventures.

There are two main reasons frequently cited to justify the creation of these parks: First, that the clustering of universities, research institutions and technology-based firms in a specific region promotes the creation of formal and informal communication channels (largely through personal contacts) that facilitates the exchange of ideas, knowledge and technologies, therefore creating a synergistic effect in the R&D activities of the region. And second, that the construction of technology parks contributes to the growth of existing firms and promotes the creation of new ones (many of which are founded by students, researchers or professors from the universities of the region), therefore fostering the creation of jobs and ultimately, the economic well-being of the region (Escorsa, 1991).

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19 Escorsa, P., (1991), "Parques Tecnológicos: Una Evaluación de las Experiencias Europea y Norteamericana", Memorias del IV Seminario de Gestión Tecnológica, Caracas, Venezuela, pp. 267-274

The first experience in the establishment of technology parks dates back to the 1930's when an initiative of the University of Stanford (in California, US) gave origin to the foundation, in 1953, of the Stanford Industrial Park (Escorsa, 1991). The creation of this park, eventually made possible the phenomenon of Silicon Valley, a region around Palo Alto, California which has the largest concentration of high tech firms in the world and that employed, back in 1991, around 35,000 persons.[20] A similar phenomenon occurred in the state of Massachusetts (US), with the establishment of many high tech companies along 30 km of an industrial corridor in Route 128. Many of these firms participated in industries such as microelectronics and aerospace and were largely attracted to the region because of its closeness to MIT, one of the world's top leading institutions in research and education in these areas. Other examples of technology parks in the US are Austin, Texas (Dos Santos & Parejo, 1991), Research Triangle Park, in North Carolina (OECD, 1985), and Rensselaer Technology Park, in New York (Dos Santos & Parejo, 1991).

In Europe, countries like Germany, the UK, France, Spain, Italy, the Netherlands and Finland have been actively promoting the establishment of technology parks. Examples that can be cited in the UK (Mackenzie & Rhys, 1985) include the Ricarton Research Park, linked to Heriot-Watt University with 6 companies established and employing 250 graduates; Trinity Science Park, located next to Cambridge University with more than 45 companies; Manchester Science Park with 11 firms established and 21 more that were in incubating process in 1991. In France (Dos Santos & Parejo, 1991), classic examples are Sophia Antipolis in the Cote-d'Azur region, next to the city of Nice. In 1985 the park had 490 established firms, 171 schools, centers and foundations, employed 9600 people and generated 6.3 billions of French francs per year . Another example in France is ZIRST

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20 Dos Santos, S. & Parejo, M., (1991), "Parques Tecnológicos: Un Analíse Comparativa de Experiencias Consolidadas de Países Desenvolvidos e Iniciativas de Países Latinoamericanos", in Memorias del IV Seminario de Gestión Tecnológica, Caracas, Venezuela, pp. 255-265

(Zone for the Innovation and Scientific and Technological Realization), established in the Grenoble region and housing 170 firms (of which more than 100 were created as a direct consequence of the foundation of the park) and employing 4000 people. In Latin America, countries like Brazil have had some interesting experiences like, for example, the Campinas Technology Park (61 firms principally in the telecommunications, chemical and information systems industries) and the Sao Carlos Technology Park, next to Sao Paulo University (with 52 participating firms). Other countries like Mexico, Venezuela and Colombia are now starting to follow the steps of some of these countries and are currently planning the construction of technology parks of this sort.

II.4.10 Centers of Excellence

Many RDO's have realized the convenience of setting centers specialized in the study of issues relevant to the industrial sector. In these "centers of excellence", researchers spend their time analyzing aspects of total quality management, organizational behavior, productivity and other areas that may be of interest to industry. As a result, it is not surprising to observe how many of them have succeeded because they are normally capable of finding sponsors within the state or federal government or from various industries. For example, in the US, the Ohio's Thomas Edison Program and the Arizona's State's Excellence Engineering Program were both founded primarily with the support of states' governments (Peters & Fusfeld, 1982).

II.5 Requirements for Successful Interaction

Although it must be noted that there is no such thing as a formula for success, the experiences drawn from literally hundreds of attempts to link RDO's with industry more effectively can be used to identify various factors that can be critical for success. However, it is important to have in mind that each particular case is different. At the end, the effectiveness of each alternative will depend on the needs of the firms, on the

capabilities of RDO's to satisfy those needs and on the particular context in which the interaction occurs.

Table II.5.1 show some of the principal factors that have been identified from the literature as instrumental for the success of many interaction programs (Mackenzie & Rhys, 1985; Solleiro, 1990; SRI International, 1986[21]). The factors have been arranged according to the same criteria used to classify the principal motivations and barriers for RDO's - industry interaction to stress which organizations or sectors need to be concerned in each case.

As can be seen from Table II.5.1, there are four factors that cut across the different levels of analysis. This is so, because they represent integration factors that bring together individuals and organizations with the much broader context represented by the structural conditions. First, the physical proximity of certain industries and government bodies will exert certain influence on the areas of research performed at nearby RDO's (e.g. biotechnology in the Boston area). Second, the existence of proactive leaders is crucial to develop relations and to promote an environment supportive of those relations in RDO's, government and industry. These leaders frequently have to convince individuals and organizations of the benefits of the interaction, work as translators between the two sectors and help to settle conflicts and disputes that may arise during the relationship.

Third, the existence of good internal and external communications is absolutely essential to identify opportunities, anticipate constraints and improve coordination, particularly across different sectors. And finally, although it is desirable to assume attitudes and set policies, procedures and regulations to manage the interaction, it is always convenient to

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21 SRI International, (1986), "The Higher Education-Economic Development Connection: Emerging Roles for Public Colleges and Universities in a Changing Economy" , American Association of States and Colleges (Editors), Washington, D.C., U.S.

Table II.5.1 Success Factors for RDO's - Industry Collaboration

STRUCTURAL	INSTITUTIONAL OR PROCEDURAL	INDIVIDUAL OR MOTIVATIONAL
• Creation of fiscal incentives to promote collaboration (e.g. tax exemptions, investment tax credits. etc.) • Establishment of programs to fund collaborative efforts between RDO's and industry	• Clarity of objectives and parameters of evaluation of researchers, projects and programs • Existence of adequate institutional capacity in terms of expertise, facilities, equipment and financial resources for the interaction • Establishment of adequate organizational arrangements to promote and manage the interaction • Categorization of collaboration agreements and definition of policies to regulate each agreement; for example, for contract research, consulting, etc. • Formulation of clear policies regarding: - income generation, administration of funds and distribution of earnings - intellectual property protection - evaluation schemes - monetary incentives and rewards - promotional systems • Good program administration • Availability of adequate legal support	• Good will, trust and confidence in the other party • Previous experience in collaborative efforts between the two sectors • Promotion of dialogue between individuals with compatible technical or managerial backgrounds to ease communication
• Strategic location of RDO's with respect to industry, government agencies, etc.		
• Strong, proactive leadership to overcome barriers, develop relations and promote the interaction		
• Good communications (formal and informal networks to allow for the flow of information and the establishment of relations between RDO's and the public and private sectors)		
• Flexibility provided at all levels to allow for the match of specific industry needs with RDO's capabilities under different conditions, circumstances and contexts.		

allow for a certain degree of flexibility: a) to accommodate for particular needs, circumstances or requirements that may not have been anticipated, and b) to leave enough room to modify or adjust the programs as experience in running them is gained.

Chapter Three: R&D Organizations - Industry Interaction in Mexico

III.1 Introduction

The preceding Chapter presented a general overview of the phenomena of RDO's - Industry interaction including the experiences of many organizations around the world. However, as the ultimate purpose of this work is to study the chances of a particular RDO to successfully interact with industry, it is now necessary to start narrowing down the analysis. For this reason, this Chapter presents an overview of those structural, procedural and institutional factors that influence the establishment and maintenance of relations between RDO's and industry for the particular case of Mexico. To complement this presentation, the Chapter ends with a brief description of some interaction programs that have been successfully implemented in the country.

III.2 Structural Conditions

As mentioned in the previous Chapter, the structural conditions related to RDO's - Industry interaction are those determinants deriving from economic, political and technological spheres which have a wide influence over institutions and individuals involved in the process, motivating or preventing the interaction (López et al., 1992). However, it is important to mention that the opposite is not always true as the individuals and/or institutions directly involved in the interaction are rarely able to influence these structural conditions. Therefore, in this sense, these conditions can be thought off as constituting the context surrounding the interaction. Following, is a description of the most important factors that need to be considered to analyze the phenomena of interaction in the case of Mexico.

III.2.1 International Context

As a developing country, Mexico continues to be dependent upon and vulnerable to a broad set of international and economic conditions. The new world economic order is forcing Mexico to confront important challenges but at the same time is offering important opportunities for development.

Undoubtedly, from all the changes occurring in the economic order, the worldwide revolution of production systems is one of the most relevant for less developed countries like Mexico because of its broad technical, economic, political and social implications.

The scientific and technological advances of developed countries in areas such as microelectronics, biotechnology and materials science are completely revolutionizing manufacturing systems, production processes and the ultimate characteristics of their goods and services. These advances, coupled with innovations in organizational systems and management structures are allowing DC's to achieve exceptionally high levels of productivity and to produce goods and services of superior quality. As a result, these countries have been able to increase the efficiency of their production systems and therefore, to optimize the use of resources traditionally abundant in developing countries (e.g. raw materials, labor, energy, etc.). In this way, they have been able to capitalize their investment in R&D projects and to translate it into an element of competitive advantage over LDC's.[22]

A direct consequence of this situation is that LDC's like Mexico are now facing a decline in the structural demand of those production factors that traditionally gave them a comparative advantage over industrialized countries. The development of new materials

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[22] This capitalization of DC's R&D efforts has not only been achieved through reductions in costs resulting from improvements in their production processes but also through an increase in the value-added of their products and services derived from aspects such as quality improvements or the inclusion of innovative features.

has reduced the demand for more traditional ones usually produced in developing countries (e.g. composites for aluminum); the development of more efficient or alternative production processes has reduced the demand for energy sources abundant in LDC's (e.g. coal and oil); and the modernization and automation of production lines has increased the need for highly trained personnel subsequently reducing the need for large numbers of unskilled, cheap labor, frequently found at developing countries.

On the other hand, the decline in demand for raw materials and traditional sources of energy (which constitute the main exports of many developing countries) has had a profound impact on international prices forcing them to fall while the prices of goods and services sold by developed countries (and imported by developing countries) continues to rise as a result of their increasing value-added.

In summary, as stated by de María y Campos[23], "the technological revolution is allowing developed countries to consolidate in areas in which they have been traditionally strong, to regain those they were losing to less developed countries - like textiles - and to develop new products to give them the lead in high-tech fields."

In addition to these advantages, the present trends towards the internationalization of services and the globalization of commerce are reinforcing the position of developed countries. For example, the development of modern communication systems and the reduction of transaction costs is allowing some transnational corporations to coordinate and integrate better the activities of their plants, facilities and offices around the world. Similarly, recent attempts for regional integration are substantially modifying the structure of many industries and the terms of competition. For example, the harmonization of policies and standards in the European Union is allowing firms

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[23] De María y Campos, M., (1988), "México Frente a los Retos de la Nueva Revolución Tecnológica", in Comercio Exterior, SECOFI, Mexico City, Mexico, vol. 38, issue 12, pp. 1084-1094

established in Europe to exploit economies of scale by supplying many countries from single-large scale facilities. As a result, some firms from developed countries are now better suited to exploit their comparative and competitive advantages on a worldwide basis.

Finally, there is another worldwide trend significantly affecting technological development. That is, the current attitude of many firms from developing countries towards the appropriation of technology. Due to the increasing contribution of technology to the value-added of modern products and processes, to their short life-cycles, and to the uprising costs of R&D in certain fields (e.g. biotechnology), many firms are opting to limit the access of third parties (especially competitors) to these technologies.

This strategy presents three negative aspects (de María y Campos, 1988). First, there is a tendency to grant fewer licenses and export directly (or when this is not possible to directly invest). This strategy is now being facilitated by the adoption of liberalization policies and the implementation of more attractive foreign direct investment policies in many developing countries. Second, modern technologies are being sold at higher prices than before and their sale is subject to more restrictions. And third, transnational corporations have been exercising significant pressure on developing countries to modify their intellectual property legislation. In this case, particularly relevant has been the pressure exercised by the US through international fora such as the Uruguay Round of the General Agreement of Tariffs and Trade (GATT). The aim has been to try to standardize the terms and protection offered by intellectual property policies according to developed country standards (especially to those of the US).

III.2.2 Economic Conditions

The 1980's represented for Mexico and many other Latin American countries a decade full of difficulties and challenges during which the world saw one country after another fall into deep economic recessions. For Mexico, the 1982 drop of oil prices (which accounted for 78% of total Mexican exports at the time) marked the beginning of a crisis of foreign exchange that drained the federal reserves and triggered inflation to a rate of 58.9% per year.[24] The public deficit rose to 16.9% of GDP and forced the government to rely increasingly on international loans to service a foreign debt that in those days totaled $82 billion (Grindle, 1993). In the second half of the decade the situation was aggravated when two powerful earthquakes hit Mexico City in September of 1985, provoking losses of more than $5 billion in damages; by a further drop of oil prices in 1986; and by a crash of the Mexican stock market in 1987. By 1988, the foreign debt well exceeded $100 billion and inflation was near 130% per year (Grindle, 1993).

In 1988 the government took steps to renegotiate the foreign debt with its international creditors and signed a stabilization agreement with the IMF. The agreement with the IMF required the implementation of a structural adjustment program that mandated, among other measures a strict control of public expenditure to reduce inflation and to correct desequilibria of the balance of payments. This reduction of government expenditure has had profound effects in the Mexican economy. The contraction of public investment in the productive sector and in social programs such as education and public works, provoked a slowdown in economic growth because in Mexico the government has been traditionally a main motor of the Mexican economy. As explained further on, this situation has had profound effects in the productive sector and in government efforts to promote technological development.

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[24] Grindle, M.. S., (1993), "Lecture on the Politics of Development Policies in the Third World", Harvard's Kennedy School of Government, Cambridge, Massachusetts, U.S.

III.2.3 Industrial Structure and Commercial Policies

During most of this century, Mexico as many other developing countries (especially those in Latin America), primarily followed a strategy of import substitution to promote the industrial and economic development of the country.[25] However, during the 1980's this strategy had to be substantially modified as a result of the economic crisis. With the fall of oil prices, it became clear that the country could no longer continue to rely on external borrowing to finance industrialization as the lack of foreign currency made it increasingly difficult to service the debt. At the same time, growing protectionism from industrialized countries and rising international interest rates complicated the situation even more.[26]

By the mid-1980's, the government realized that significant policy changes were required if the country were to come out of the crisis. First, as explained earlier, stabilization measures were adopted as a result of the signature of an agreement with the IMF. This meant the imposition of severe fiscal restraints and monetary controls that provoked a reduction of public and private investment in the productive sector. Second, the state undertook an unprecedented privatization effort among developing countries to permit the development of a more open market economy. This meant that the participation of the government in the productive sector were to be more selective (e.g. in certain priority sectors such as energy) and even in those cases, limited only to certain activities. And third, the opening of domestic markets by removing restrictions on foreign investment in priority sectors such as telecommunications and banking. In addition, the government has followed since 1985, a policy of liberalization of trade that started with the entry of

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25 Import substitution industrialization can be very broadly characterized as a shift from import to the local manufacture of consumer goods (e.g. food processing and clothing), some technology-intensive goods like consumer durables (e.g. automobiles), intermediate goods (e.g. cement and steel), and certain capital goods (e.g. heavy machinery).

26 Gereffi, G., (1991), "International Economics and Domestic Policies", Chapter 9 in Economy and Society: State of the Art, Sage Publications, Newbury Park, California, U.S., pp. 231-258

Mexico into GATT and that eventually resulted in the signature of the North American Free Trade Agreement (NAFTA) between Canada. Mexico and the US.

From an industry perspective, there are many implications that can be drawn from these policies. However, in general they all can be summarized into just two words: greater competition. The Mexican industry, accustomed of being protected from foreign competition by import restrictions such as tariffs and quotas, grew up without needing to reach the levels of innovation, quality and productivity required today to compete successfully with foreign firms and on the same ground. This condition is complicated by the fact that most of these firms will need to compete under severe limitations as, in Mexico, between 90 to 95% of the Mexican firms are small or medium-sized.

III.2.4 Scientific and Technological Development

In Mexico it has been traditionally taken for granted that the prime responsibility in the promotion and development of science and technology corresponds to the state. In fact, according to the Mexican "Law to Coordinate and Promote Scientific and Technological Development" (LCPDST), it is the responsibility of the state to coordinate the activities of the National System of Science and Technology (SINCYT). The SINCYT, is integrated by all the federal agencies and public bodies that participate in the creation of scientific and technological knowledge and in its integration into the productive sector; by all the norms and policies that regulate their functions and activities; by all the state's actions intended to stimulate, promote and finance the generation, diffusion and application of science and technology; and by those organizations, groups and institutions from the scientific and technological community or from the private or social sectors that are admitted to the system according to the provisions dictated by the LCPDST.

In 1990, the Mexican government formulated the National Program for Science and Technological Modernization (PNCYMT) to set the guidelines for the participation of the federal government in the promotion of the scientific and technological development of the country for the period 1990-1994. This document presents an assessment of the principal problems currently faced by the SINCYT. (see Table III.2.4.1)

From all the problems shown in Table III.2.4.1, undoubtedly the first one deserves special attention, because in Mexico, only around 0.36 % of the country's GDP (1993) is devoted to science and technology while in many DC's, this percentage normally fluctuates between 2 to 3% of GDP (see Figure III.2.4.1). It is obvious that for a rapidly developing country like Mexico, this number is much smaller than needed but the economic situation of the country has severely limited the availability of resources. In fact, as a result of the economic crisis of the 1980's and just in the period from 1981 to 1993, there was a reduction, in real terms, of more than 30% in the federal expenditure in science and technology (FES&T). In 1981, the FES&T represented 0.46% of GDP while, in 1993, this value fell to 0.36% of GDP. Table III.2.4.2 show these values and Figures III.2.4.2 and III.2.4.3 illustrate them.

This reduction is particularly relevant because in Mexico, between 85 to 90% of the country's total R&D expenditure is undertaken by the Mexican government (Waissbluth, 1990). This is a condition quite contrasting with what happens in developed countries in which this participation normally fluctuates from 40 to 60% (Waissbluth, 1990). The contraction of FES&T has been primary notorious in the following areas: a) direct financial support for R&D programs performed at public research institutes, government agencies and other public bodies; b) contracting of R&D projects with private firms or other social organizations; c) the provision of incentives to promote scientific and

Table III.2.4.1 Problems Faced by the National System of Science and Technology (SINCYT) in Mexico [27]

- Lack of sufficient resources to support activities related with scientific research and technological modernization, including the development of human resources
- Incorrect allocation of public funds to support R&D efforts and lack of adequate systems to evaluate results.
- Lack of monetary incentives and low wages offered to researchers
- Lack of sufficient incentives to promote the acquisition of new technologies and the commercialization of technology
- The S&T infrastructure of the country is in bad shape and in many cases is obsolete
- Lack of appropriate infrastructure to promote the linkage between RDO's and the productive sector
- Insufficient efforts to decentralize R&D through the promotion of scientific and technological activities throughout the country
- Inadequate access to consulting services and information systems by firms and other institutions
- The country's scientific and technological community is reduced and there is lack of interest from young generations to pursue careers associated with S&T
- Education deficiencies at the primary and high-school levels and lack of attention given to the teaching of courses related with S&T
- Higher education frequently does not reach appropriate quality levels

27 Secretaría de Programación y Presupuesto - Consejo Nacional de Ciencia y Tecnología, (1990), "Programa Nacional de Ciencia y Modernización Tecnológica, 1990-1994", SPP - CONACYT, Mexico City, Mexico

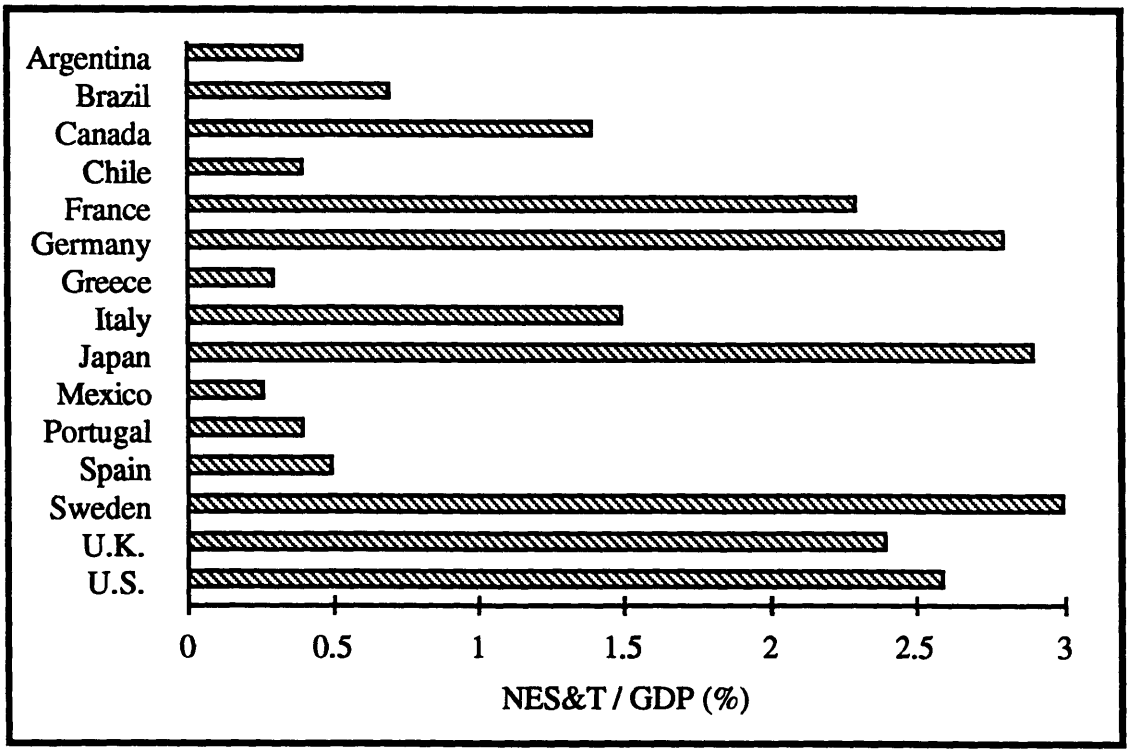

Figure III.2.4.1 National Expenditure in Science and Technology as a Percentage of the Gross Domestic Product of Selected Countries (1988) [28]

[28] National Council for Science and Technology, (1992), "Indicators - Scientific and Technological Activities, Mexico, 1992", CONACYT, Mexico City, Mexico

Table III.2.4.2 Federal Expenditure in Science and Technology in Mexico
(Millions of Dollars)

YEAR	FEDERAL EXPENDITURE IN SCIENCE & TECHNOLOGY (FES&T)		GROSS DOMESTIC PRODUCT (GDP)		FES&T GDP (%)
	Current Prices	1980 Prices	Current Prices	1980 Prices	
1980	836.3	836	194,775	194,775	0.43
1981	1144.8	1041	250,005	227,277	0.46
1982	714.7	612	170,574	146,014	0.42
1983	471.6	388	148,779	122,341	0.32
1984	646.3	509	175,667	138,233	0.37
1985	653.4	496	184,432	139,954	0.35
1986	554.5	336	129,535	95,711	0.35
1987	394.7	283	141,442	101,363	0.28
1988	466.8	322	173,512	119,680	0.27
1989	590.0	375	206,923	136,448	0.27
1990	725.0	458	244,508	154,586	0.30
1991	1049.6	638	287,737	174,916	0.36
1992	1142.6	677	329,076	194,985	0.35
1993	1244.4	718	348,706	201,378	0.36
1994	1280.8	719	368,513	204,014	0.35

Source: Consejo Nacional de Ciencia y Tecnología, (1993), "Indicadores de Actividades Científicas y Tecnológicas", CONACYT, Mexico City, Mexico

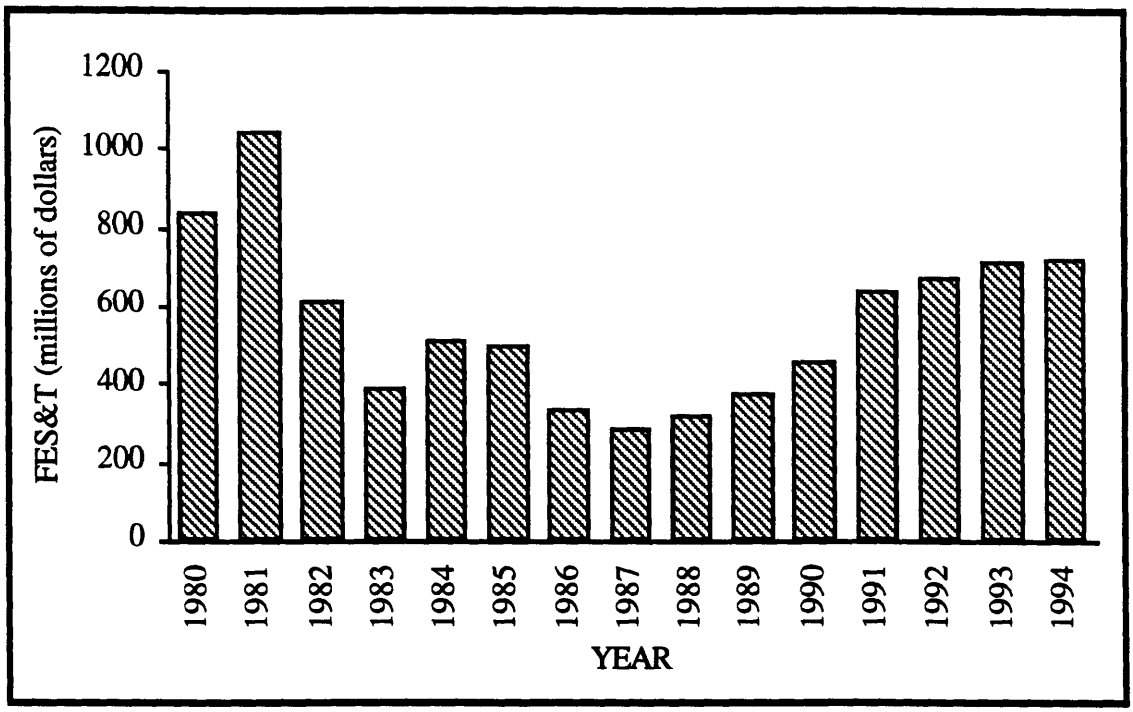

Figure III.2.4.2 Federal Expenditure in Science and Technology in Mexico (in Constant, 1980 dollars) [29]

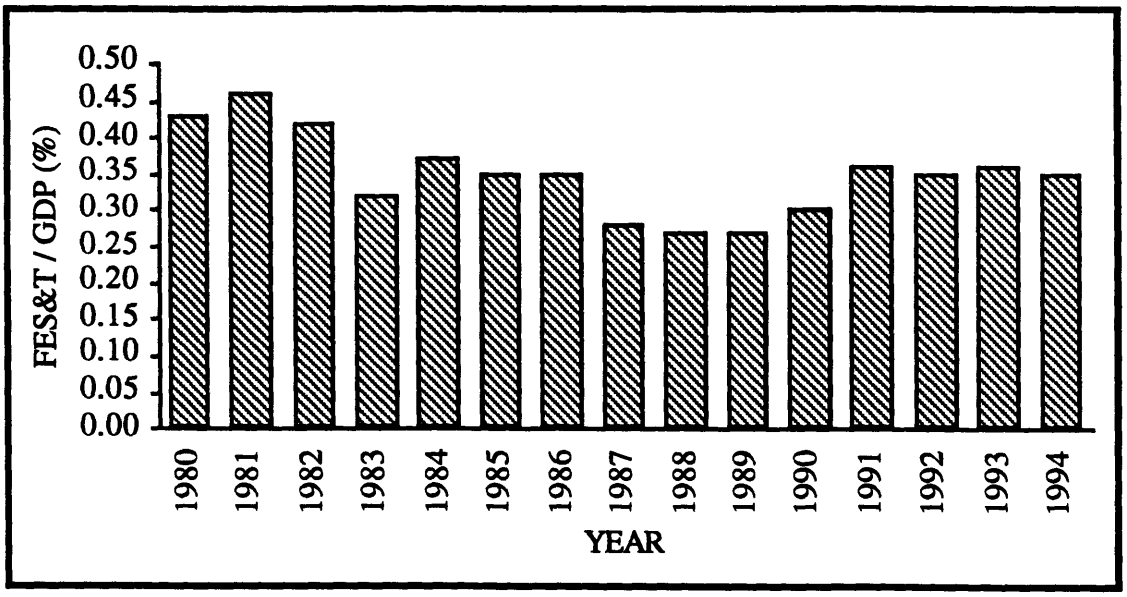

Figure III.2.4.3 Federal Expenditure in Science and Technology in Mexico as a Percentage of Gross Domestic Product [30]

[29] CONACYT (1993), op. cit.
[30] CONACYT (1993), op. cit.

technological development; and in d) direct or indirect support and/or participation in the education and training of human resources.

On the other hand, the large participation of the state in S&T matters emphasizes the small involvement of Mexican industry in science and technology. In fact, there are estimates that only 65 out of a total of 200,000 firms operating in Mexico, perform some sort of in-house R&D activities in the country.[31] This lack of tradition of the Mexican industry to participate in R&D efforts is especially troublesome because in developed countries, industry represents a major driver for technological development.

Even though, it seems that in Mexico many industrialists are not interested in getting involved in R&D activities to develop their own technologies or to adapt technologies acquired abroad; either they are risk averse, lack the financial resources or simply just fail to recognize that technology should not be viewed as merely another production factor but as a key element of their corporate strategy. Rather, they normally prefer to acquire mature technologies from countries in which those technologies have previously been tested. The problem is that frequently by the time these technologies are acquired, most of their life cycle has expired therefore rendering them obsolete. Certainly this would not constitute a problem if a protectionism policy would continue to prevail in the country as firms could do relatively well with low levels of quality and productivity. But with the adoption of liberalization policies, and the entry of foreign competitors employing top-of-the-line technologies and exhibiting modern organizational systems to achieve high levels of productivity and quality, firms operating under these conditions will find it not only increasingly difficult to do financially well but simply to survive.

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31 Solleiro, J.L., (1990), "La Vinculación de la Universidad Nacional Autónoma de México con el Sector Productivo", Working Document, CIT-UNAM, Mexico City, Mexico

Besides this lack of tradition to invest in R&D, the economic crisis of the country contributed to worsen the situation even more. The economic recession meant a generalized decline in demand (especially because the profitability of many firms depends on their sales to the government), high interest rates, scarcity of capital and credits and, in general, a reduction in productive investments. As a result the few firms performing R&D were forced to cut their expenditures in these areas and to postpone any modernization plans that they might have had.

III.2.4.1 Financial Support for R&D and Fiscal Incentives

Even though the federal government has been forced to reduce its overall expenditure in S&T, there are still some institutions and programs that continue to offer some sort of financial support to sustain the scientific and technological efforts of the country. This is the case of public entities such as the National Council of Science and Technology (CONACYT), of the Secretariat of Public Education (SEP) and of some financial creditors like Nacional Financiera (NAFINSA).

Among these, the support provided by CONACYT has been particularly important. As CONACYT is one of the main channels through which federal resources flow to support S&T, for many years the Council has been located at the core of the scientific and technological development of the country.[32] Although traditionally the involvement of the Council in S&T matters has been rather extensive, there are certain areas in which its participation has been particularly relevant.[33] This is the case of its participation in the:

a) financial support for students performing graduate studies in Mexico and in other

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32 For example, just in 1994, CONACYT administered more than $300 million dollars. Source: Consejo Nacional de Ciencia y Tecnología, (1993), "Indicadores de Actividades Científicas y Tecnológicas", CONACYT, Mexico City, Mexico, pp. 127

33 Consejo Nacional de Ciencia y Tecnología, (1989), "CONACYT Informa, 1989", CONACYT, Mexico City, Mexico

countries (scholarships); b) financial support for scientific and technological development projects; and c) the administration of funds for the National Researchers System (SNI).[34]

With respect to more specific programs designed to provide support to industries or to promote the cooperation between RDO's and industry, there are three programs financed by CONACYT that are particularly interesting.

First, there is a program called FORCCYTEC, which is a public fund administered by a commercial bank and that is intended to finance the foundation of new R&D centers by the private sector.[35] The support provided by this program is only directed to the equipment and possible adaptation of laboratories and cannot exceed 65% of the total installation costs. The financial support offered by this program is really nothing more than a loan in which 50, 75 or 100% of the total loan (as agreed by both parts) has to be repaid to CONACYT in a maximum of 3 to 5 years. However, and despite these provisions, it seems that the results of the program are still pretty modest. The reason for this situation might be that the loans are granted based on commercial rates rather than on some sort of preferential interest rates.

Second, CONACYT has established a program to provide financial support for the development of industry incubators (PIEBT).[36] In this case, the Council can either participate directly as founder of the incubators or it can provide support to specific projects developed at the incubator through any of its programs directed to promote

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34 The National Researchers System (SNI) is an association formed by the most prestigious scientists and researchers of the country and that was established in 1984 as a result of a government initiative. The SNI operates as a federal fund, administered by CONACYT and that is used to make complementary payments to the wages of its members. Admission into the SNI depends in a rigorous process of selection and on the evaluation of special committees of prestigious researchers.

35 Consejo Nacional de Ciencia y Tecnología, (1992), "FORCCYTEC, Fondo para el Fortalecimiento de las Capacidades Científicas y Tecnológicas", Informative Brochure, CONACYT, Mexico City, Mexico

36 Consejo Nacional de Ciencia y Tecnología, (1992), "PIEBT, Programa de Incubadoras de Empresas de Base Tecnológica", Informative Brochure, CONACYT, Mexico City, Mexico

technological modernization. In any case, CONACYT's support cannot exceed 30% of the total investment costs and cannot last more than 5 years. Because PIEBT is a rather new program, it is difficult to evaluate at this point its success. However, it seems that many difficulties are being encountered at this point to implement the program.[37]

Finally, there is another program that in this case is explicitly designed to promote the linkage between RDO's and industry (PREAIN).[38] Through this program, CONACYT provides funding to promote the interaction from the two sectors in terms of: a) human resources development; b) joint research and development; and c) commercialization of technologies. In this case, CONACYT provides up to 50% of the total project costs and does not require repayment, while the RDO and industry are supposed to provide the other 50% (in this case, CONACYT normally pressures participating firms to provide at least 35% of the costs leaving the RDO to pay the rest).[39] In addition, there are several important aspects of this program that need to be mentioned. First, the program mainly provides support to projects related with the development of technologies (applied research) rather than with projects involving scientific research (basic research). This is so because there are other programs that provide wide support to this type of research (e.g. in areas such as physics, mathematics, etc.). Second, the program is characterized for being extremely flexible and therefore for allowing the accommodation of the particular needs of each project and of the specific participants involved (e.g. in terms of conditions for funding). According, to Ms. Maira, manager of the program, PREAIN has been quite successful judging from the number of applications received per year (over 100 in 1992). However, the financial resources of the program are still quite limited.[40]

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37 López, R., (1994), Personal Interview, CIT-UNAM, Mexico City, Mexico

38 Consejo Nacional de Ciencia y Tecnología, (1992), "PREAIN, Programa de Enlace Academia-Industria", Informative Brochure, CONACYT, Mexico City, Mexico

39 Maira, G., (1994), Personal Interview, CONACYT, Mexico City, Mexico

40 In 1993 the program operated with a fund of merely $2.2 million dollars

Finally, the government has established a group of fiscal incentives to promote the involvement of RDO's, technology-based firms, national firms operating in the productive sector and individuals in general, in the development of S&T.[41] These incentives take the form of tax exemptions, normally equivalent to 20% of the total investment costs to cover aspects such as the acquisition of equipment and machinery, the construction of auxiliary facilities or the contracting or direct involvement in the performance of R&D projects.[42] In the case in which the firms involved in these activities are micro or small-sized, the tax exemption are normally equivalent to 30% of the costs, while for individuals acquiring technology or contracting services related with S&T such as consulting for the adaptation and assimilation of technology, the percentage is equivalent to 15%.[43] Finally, in the case in which the technology is imported the government allows federal tax deductions equivalent to 100% of import taxes.

III.2.5 Intellectual Property Policies

In order to establish intellectual property policies congruent with the commercial and industrial policies adopted in the country during the late 1980's, in June 27, 1991, the Official Diary of the Federation published the Law for the Promotion and Protection of Industrial Property (LFPPI).[44] With the enactment of this new Law (which abrogated the Law for the Control and Registration of Technology Transfer and the Use and Exploitation of Patents and Trademarks) it became clear that a completely new mentality was developing in the country regarding the appropriate protection of intellectual property. As a result, Mexico now offers intellectual property protection (IPP) that can

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41 Consejo Nacional de Ciencia y Tecnología, (1987), "Marco de Aplicación de Estímulos Fiscales y Exención de Impuestos Establecidos en Diversos Ordenamientos Legales Actualmente en Vigor", CONACYT, Mexico City, Mexico

42 It is important to point out, however, that there are several restrictions and requirements to gain access to these benefits, depending in issues such as the type of institutions involved (e.g. RDO's), the origin of the equipment bought (national or foreign), etc.

43 Micro and small-size firms are those employing no more than 100 persons and with net sales inferior to $325,000 dollars per year.

44 Villareal, R., (November, 1991), "La Nueva Ley Mexicana en Materia de Propiedad Intellectual", in Comercio Exterior, SECOFI, Mexico City, Mexico, vol. 41, issue 11, pp. 1057-1065

be considered quite similar to that offered by most developed countries (in particular by the U.S.).[45]

As most of the laws enacted for the protection of intellectual property, the enactment of the LFPPI is mainly intended to promote the scientific and technological development of the country.[46] Instruments such as patents and copyrights are means to, on the one hand, reward authors and inventors for their creativity and capacity to innovate and, on the other, to provide incentives to promote a more active involvement of students, professors, researchers, industrialists and society in general in the development of science and technology.

Therefore, the new Law incorporates several provisions to function as incentives to promote this participation. Provisions such as the extension of patent protection from 14 to 20 years (starting from the date the application is filed); the authorization for granting patents for innovations in areas in which it was previously forbidden (e.g. for chemical products, microorganisms, vegetable varieties, alloys, biotechnology and genetically engineering products, etc.); the reduction in the number of situations in which compulsory licensing will be enforced (e.g. under critical conditions such as scarcity of certain products); or authorization for granting petty patents in the country, etc., all are supposed to work as incentives to promote scientific and technological development.[47]

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45 This is an interesting observation because in Mexico, intellectual property protection policies have been traditionally inspired by those adopted in European countries and by international organizations such as the Intellectual Property World Organization. However, it seems that in this case the pressure exercised by the US (particularly through negotiations of the Uruguay Round of GATT) to adopt more liberal intellectual property policies finally paid its fruits.

46 Serrano, F., (1992), "La Propiedad Industrial en México (Nueva Ley para su Fomento y Protección)", Editorial Porrúa, S.A., Mexico City, Mexico

47 A "petty" patent is a type of patent granted to a product or process that has been adapted for a new application or that offers certain advantages in its usefulness (e.g. as a result of modifications in its structure).

Finally, an additional aspect of the new Law that is extremely important is that it mandated the disappearance of the National Registrar for Technology Transfer (RNTP). The Registrar, which was set in place at the beginning of the 1970's, was intended to set the general conditions for the negotiation of licensing and technology transfer agreements in the country. In this way, the Mexican government directly supervised and controlled all these activities since any licensing or technology transfer agreement signed in the country required approval from the government. However, with the increasingly important insertion of Mexico in the international economy and with the increase the level of competition in the business environment of the country, it became evident that the RNTP had to be eliminated. If the state really was to set appropriate conditions for the development of a competitive Mexican industry, it was necessary to provide firms with enough freedom to negotiate their own licensing and technology transfer contracts.[48] In this way, firms would be able to respond more efficiently, for example, to the threats of competitors.

III.3 Institutional Factors

In Mexico, most of the factors affecting the interaction between RDO's and Industry are similar to those presented in the preceding Chapter (see Tables II.2.1.2 and II.2.2.2). Rather than repeating again all of these factors, this section presents a broader description of those that are particular relevant to analyze the process of RDO's - Industry interaction in the country.

III.3.1 Bureaucratic Procedures and Regulations

As mentioned before, in Mexico, as in many other developing countries, the state plays a fundamental role in the promotion and direct undertaking of activities related to the

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[48] Toledo, J., (November, 1991), "Justificaciones de Política Industrial y Comercial para Abrogar la Ley de Transferencia de Tecnología", in Comercio Exterior, SECOFI, Mexico City, Mexico, vol. 41, issue 11, pp. 1036-1040

scientific and technological development of the country. As a consequence of this active participation, individuals, institutions and organizations involved in the process have to perform their functions in a climate full of long and tedious bureaucratic procedures. Moreover, the specific characteristics of the Mexican State seem to complicate things even more than in similar countries in which the government has also a wide participation in activities of this sort.

Most of the publicly funded RDO's, government agencies and public bodies involved directly or indirectly in the SINCYT, seem to be characterized for being extremely hierarchical organizations in which clientilistic and patronage relationships tend to prevail. As a result, institutions such as publicly funded universities have adopted strict internal regulations and procedures that can constitute very important barriers not only for the establishment of cooperation programs with industry but also for the efficient performance of most of their duties.

Undoubtedly, the most visible impact of bureaucratic procedures can be the discouragement of individuals involved in the interaction. A scientist that needs to wait months to get approval for a research project might finally decide not to go ahead with this project simply because he lost interest in the research of because the right time for performing the research has passed. Similarly, a failure to submit the results of a research project on time because a repair piece for a lab equipment was supplied two or three months after it was requested (because of formal acquisition procedures) may create a lack of trust and confidence in the project sponsor for both the university and its researchers.

Even though barriers such as these are clearly visible, this does not mean that it is easy to overcome them. The modification of internal regulations and procedures normally means

shifts in power and lines of authority. Therefore, it is possible to encounter significant resistance to these changes, especially from bureaucracy itself. However, if attempts to improve the interaction of RDO's with industry are to be successful it is absolutely essential to try to set up more flexible procedures to really facilitate such interaction.

III.3.2 Lack of Resources

Among the multiple needs for adequate material, financial and human resources to participate in interaction programs with industry, there is one factor that seems to be considerably affecting the capacity of several RDO's in Mexico to interact with industry. It seems that especially at publicly-funded universities, there is a lack or not enough qualified human resources to adequately take care of teaching and research activities simultaneously.[49] Researchers from many of these organizations complain that their teaching activities leave them with little time to spend in their research programs. This is both because of the small number of researchers and/or professors as well as because of the lack of sufficient academic support for their efforts (e.g. teaching assistants).

III.4 Individual Factors

Again, in the case of the individual factors affecting the interaction, all of the factors presented in Chapter two, seem to be important in the case of Mexico. However, the structural and institutional factors affecting the interaction in the country seem to stress even more the importance of motivations and barriers at the individual level. For example, the traditional lack of cooperation between universities and industry makes the collaboration more desirable for both sectors but at the same makes it more difficult to overcome barriers such as the lack of confidence and trust. In the case of Mexico, the following factors seem to be especially important.

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[49] According to Solleiro (personal interview, 1994), this is the case, for example, of many professors and researchers working at the National Autonomous University of Mexico (UNAM).

III.4.1 Personal Income

In contrast with most DC's, the salaries paid to scientists and researchers in Mexico are extremely low, especially for those working for publicly-funded universities. As a result, these institutions are normally troubled by high turnover rates or in the best of cases are forced to allow their personnel to spend a considerable part of their working time performing other activities (e.g. managing their own businesses or providing personal services such as consulting). This situation is complicated by their small chance of generating income from research related activities, even if these are sponsored by industry. For example, there are many RDO's in Mexico which do not allow royalty payments to be made to researchers as a result of the patenting of their own innovations.

III.4.2 Recognition and Prestige

Unfortunately, in Mexico most professors and researchers do not enjoy the same level of social recognition and prestige than some of their colleagues from other countries. Undoubtedly a good explanation for this situation is their lack of visibility within society because there is not enough promotion of their accomplishments. Certainly, a greater interaction with industry is in this sense, a good opportunity to try to enhance their prestige and to expand that prestige to sectors other than the academic.

III.5 Some Successful Experiences with the Interaction in Mexico

The purpose of this section is to present a brief description of the experiences of some institutions with regard to the implementation of programs to link RDO's and the Mexican industry. The analysis of experiences such as these together with the overview presented in Chapter Two, provided insights that were extremely useful to understand the problematic associated with the interaction as well as to visualize possible solutions to these problems.

In particular, the experiences of two institutions were very valuable. First, those related with the Center for Technological Innovation (CIT), of the National Autonomous University of Mexico (UNAM); and second, those from the Institute of Electrical Research (IIE).

III.5.1 The Center for Technological Innovation (CIT)

The Center for Technological Innovation is a branch of UNAM, the largest public university in Mexico.[50] CIT was founded in 1985 but its origins can be traced back to 1983 when the General Direction for Technological Development, its predecessor, was created. The operational budget of CIT mostly comes from UNAM and almost all of its personnel consists of academics.[51]

CIT was created with the explicit objective of linking the scientific and technological potential of UNAM with the demands of the industrial sector. This is mainly done through the provision of management services to facilitate technology transfer from the university to industry. In addition, the center is actively engaged in research in areas such as technological innovation, the study of science and technology policies and technology management as well as in the education and training of professionals in these areas. In this sense, its activities are typical of the technological innovation centers described in the preceding Chapter. However, CIT's engagement in activities such as technology licensing, the negotiation of research contracts and the search for potential industrial partners or sponsors, makes the center assume functions that are typical of other organizational structures such as industrial liaison programs or technology licensing

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50 Until 1990, the research capabilities of UNAM were concentrated in 22 research institutes, 13 research centers, 2 general directions and 3 university programs employing more than 2500 researchers (without taking into account the research performed at the individual schools - e.g. engineering, chemistry, biology, etc.). In 1985, the university was engaged in more than 3370 research projects.

51 Quantitatively, more than 20% of UNAM's budget is used to support research (more than $400 million dollars per year). Source: Solleiro, J.L., (1990), op. cit.

offices. Table III.5.1 presents the evolution of the services provided by CIT from 1985 to 1989.

Besides these activities, CIT has been actively involved in the establishment of more complex organizational structures for the interaction. This is the case, of its involvement in the creation of the Center for Electronic Technology and Information Systems (CETEI) with the support of the National Chamber for the Electronic Industry and Electrical Communications (CANICECE) and UNAM; of its participation in the foundation of the "Morelos" Technology Park in conjunction with the Institute of Electrical Research, the Association of Industrialists from Morelos, Nacional Financiera (NAFINSA) and the Government of the state of Morelos; the creation of the SOMEX-UNAM fund which provides direct financial support for technological research at UNAM; and its participation in the negotiation of long term cooperative research agreements with large corporate groups like the one signed between CONDUMEX (one of the leading manufacturers of cable and electric equipment in Mexico) and UNAM.[52]

The experience of CIT provided valuable insights into the specific factors that can determine the success or failure of interaction programs in similar institutions in Mexico. Among the factors that seem to be critical for success, it is particularly interesting that those projects in which personnel from CIT actively followed the interaction (even after the contract was signed) were considerably more successful than those in which the participation of the center ended with the signing of a contract. Factors like these seem to emphasize that in countries like Mexico, a proactive participation of technology managers throughout the entire interaction process is

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52 This agreement involves different mechanisms for the interaction including contract research, joint product development, consulting, workshops, seminars, sabbaticals, scholarships and awards. According to Solleiro (1990), only 18 months after its creation the agreement already have given origin to 40 collaboration contracts and channeled more than 300,000 U.S. dollars to UNAM.

Table III.5.1 Services Provided by UNAM's Center for Technological Innovation (CIT) to Support Technological Innovation Projects.

TYPE OF SERVICE	1985	1986	1987	1988	1989	TOTAL
Search for specialized technical information	4	8	17	17	20	66
Consulting in issues related with intellectual property protection	8	8	8	30	36	90
Consulting in project direction	8	6	18	30	36	98
Search and linkage with firms	27	29	30	25	30	141
Formulation and negotiation of contracts	22	34	39	36	43	171
Follow-up from projects already contracted	27	43	60	83	99	312
Procurement of financial resources	5	1	9	11	2	28
Technology consulting	2	3	3	5	6	19
Search and contracting of experts	2	2	1	5	-	10
Feasibility studies	-	5	7	7	23	42
Total	105	139	192	249	295	980

Source: Solleiro J.L., (1990), op. cit.

absolutely crucial. Similarly, those projects for which there was a clear market demand or those in which the principal researcher had high qualifications were also considerably successful. In contrast, those projects in which the sponsors were firms with credit or financial difficulties, those that were not properly supervised by CIT or those that

involved considerable conflicts between researchers and entrepreneurs were the ones that most frequently failed.

Finally, with respect to the success of the Center as such, it is important to mention that several factors converged to make possible its accomplishments. First, its integration into one of the most prestigious and better equipped universities of the country (in terms of human, financial and material resources). Second, the existence of adequate regulations and norms within the university to handle issues related with contract research, technology licensing and distribution of income (e.g. distribution of royalty payments among the central administration, schools and researchers). Third, its integration into a large communication network including not only the research centers and schools of the university but also multiple institutions within the public and private sectors. Fourth, the vast knowledge and understanding of its personnel of the problematic associated with the process of university-industry interaction as well as of the technological innovation process. And finally, the proactive leadership of its members in the promotion of RDO's - Industry interaction as well as in the overcoming of barriers encountered for such interaction.

III.5.2 The Institute of Electrical Research (IIE)

The Institute of Electrical Research was founded in 1975 as a result of a presidential decree that consolidated the institute as a decentralized public organization with independent juridical status and its own patrimony. The IIE was created "to promote and support technological innovation within the electric sector and among its suppliers and users through applied research, technological development and specialized technical services". [53]

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53 Instituto de Investigaciones Eléctricas, "Technological Developments and Services", Informative Brochure, IIE, Cuernavaca, Morelos, Mexico

The IIE currently employs more than 750 researchers in a wide variety of fields of expertise and has over 25 laboratories and 20 experimental installations scattered across the country. At this point its financial resources (approximately $43 million dollars in 1992)[54] come from three sources (1/3 each): from the federal government in the form of a direct subsidy; from the Federal Electricity Commission (CFE) and from contracts and agreements with other institutions in the industrial and other sectors.[55]

As a result of its mission, the managers and researchers of the institute have always recognized that it is absolutely essential to link the development of the institute to the needs of the industrial sector. Because of this perception, the IIE has always adopted a proactive attitude towards the establishment of collaboration agreements with industry. However, it is important to mention that the activities of the IIE have always been tightly linked to the needs of the CFE. This is a somewhat understandable condition, because the Commission is the "natural" customer of the institute. Besides, the type of projects funded by the CFE and the federal government tend to be different from those funded by industry. As usual, industry is more interested in funding applied, short term projects, while CFE and the federal government are usually more interested in funding basic research, with a more long-term horizon (e.g. for pollution control).

The recognition of the importance of linking the activities of the IIE with the needs of the electric sector have driven the institute to implement several mechanisms to commercialize their technology and to interact with the industrial sector. In general, the institute has followed three trends to achieve these objectives. First, the promotion and foundation of spin-offs to commercialize some of the mature technologies developed at

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54 Instituto de Investigaciones Eléctricas, "Informe Anual 1992", IIE, Cuernavaca, Morelos, Mexico

55 These include, for example, resources to support specific projects coming from institutions such as CONACYT or NAFINSA as well as from other national or international organizations.

the institute.[56] Second, an active participation in the project of the "Morelos Technology Park" to promote the commercialization of technologies through firms established in this park.[57] And third, the direct sale of technologies and the negotiation of technology transfer contracts.[58] Besides, the institute is also actively engaged in the provision of specialized technical services (e.g. consulting) as complementary means to commercialize their technology and to capture additional income.

As can be seen from the information previously presented, the IIE has been very successful in its interaction with industry and ultimately in the commercialization of its technology. An overview of their experiences pointed out the following aspects as the main reasons that can be attributed to its success. First, its juridical status and its own patrimony give the institute considerable autonomy and liberty to pursue their objectives through the means it deems more appropriate. Second, since the moment of its creation the institute has grown reasonably close to the industrial sector. Third, research projects are selected explicitly taking into account their potential for commercialization. Fourth, there is active participation of industrialists, researchers, and managers in the evaluation and selection of projects and lines of research. Fifth, the availability of important state-of-the-art facilities as well as the excellence of its technical expertise has enhanced the prestige of the institute in the sector. Sixth, the implementation of incentive and promotional systems has considerably motivated the institute's personnel to achieve increasing levels of productivity and creativity. Seventh, although the institute has established general guidelines for the negotiation of contracts, it has adopted the policy of

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56 The initial attempts of the IIE to promote the creation of these spin-offs dates to 10 years ago when 3 firms were established to commercialize technologies developed at the institute in the areas of control and instrumentation, simulation and microelectronics. The firms were initially established with capital from the IIE, a private firm and the federal government. Although initially these firms were pretty successful later on it was necessary to integrate them into a single company (SIMEX), which is currently almost entirely privately owned.

57 Although the park has not yet started operations, there are already 10 member firms and the industry incubator is under construction.

58 Particularly successful has been the sale of electronic equipment like remote terminals for the the handling of information or simulators for training power plants' operators.

negotiating each contract on an individual basis to provide enough flexibility to accommodate specific requirements or provisions that may be important in the negotiation of some of them. And finally, and perhaps most important, each five years the institute develops a strategic plan in which it explicitly considers a strategy for the commercialization and management of the institute's technology within that time frame.

Chapter Four: The Mexican Institute of Water Technology and its Role in the National Hydraulic Sector of Mexico

IV.1 Introduction

The preceding chapters presented an overview of the most common problems associated with the process of RDO's - Industry interaction in several countries and in particular, in the specific case of Mexico. Starting with this chapter, the analysis of RDO's - Industry interaction is narrowed even more to analyze the chances of a particular RDO (the Mexican Institute of Water Technology - IMTA) to implement programs of this sort. In order to do so, this chapter starts by presenting a broad description of the Mexican water resources sector in which IMTA is immersed. From there on, the chapter focuses on the description of the objectives, organizational structures, regulations, procedures and research programs of the institute as well as on its general capabilities in terms of human, material and financial resources. As will be seen in the next chapters, a deep understanding of these aspects is absolutely essential to analyze and determine how should the institute respond to the challenge of strengthening its ties with the productive sector.

IV.2 The Water Resources Sector of Mexico

In Mexico, as elsewhere, water is considered a fundamental element for social and economic development; water is not only a vital element for life and the protection of health but is also a crucial input for the productive sector. As a result, all the water resources of the country as well as all those problems associated with their exploitation, use, management and protection are considered a national priority.

Although there are estimates showing that the water resources of the country will be enough to satisfy its future development needs [59], the possibility of using them will depend largely on the capacity of the nation to preserve and exploit them efficiently. However, this is a challenging task because the water resources sector is confronting many problems and the resources available for their solution are scarce. On the one hand, it is becoming evident that: a) demands for water supply from both urban and rural sectors are increasing (for domestic, commercial and industrial use, irrigation, power generation, recreation, fishery, etc.); b) the pollution of water resources like rivers, streams, lakes, lagoons, reservoirs, acquifers, seas and oceans is getting worse (both in terms of the quantity of pollutants as well as on their chemical complexity, toxicity, etc.); c) there is an overexploitation of many water resources (especially acquifers, lakes and lagoons); d) the demand for sewage systems and flood control infrastructure is considerably growing; and e) demands for water of a better quality are also growing. On the other hand, there are severe financial, material and human resources limitations within the sector and in the country to face these problems. Although considerable resources are being channeled to the sector they are just not enough to catch up with the growing demand and to deal with the complexity of many of the problems that the sector is facing.

In Mexico, the construction and operation of infrastructure for the supply and management of water resources is a tradition that dates back to several centuries. For this reason, the country has accumulated considerable experience in the planning, design, construction and equipment of large water resources projects. However, in areas such as maintenance, pollution control, efficient use and preservation, the experience is small and progress has been limited. As a result, a great emphasis is currently being placed in the sector to find appropriate solutions to problems related to these fields.

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[59] Secretaría de Recursos Hidráulicos, (1975), "Plan Nacional Hidráulico, 1975", SRH, Mexico City, Mexico

Despite this accumulated experience, it was until the mid-1920's when pertinent government commissions were created to coordinate the planning, construction and administration of the hydraulic infrastructure of the country. However, the efforts of these groups were really formalized until 1975, when the Secretariat of Water Resources (SRH) formed the Commission for the Hydraulic Plan (CPH) to develop the first National Hydraulic Plan (PHN - 1975). The plan presented the general strategy and guidelines for the development of the National Hydraulic System (SHN) of the country. Later on, in 1976, the Secretariat of Agriculture and Water Resources (SARH) substituted the SRH and in 1981 established the Commission for the National Hydraulic Plan (CPNH) to substitute CPH and to develop a new National Hydraulic Plan (PHN - 1981) to guide the development of the SHN during the 1980's.

In 1985, a decision was taken to institutionalize the special commission that elaborated the 1981 plan (CPNH) and to transform it into an organization capable of going beyond the mere performance of planning and diagnosis studies to the actual creation of operative mechanisms to solve the problems of the sector.[60] As a result , in 1986, the Mexican Institute of Water Technology (IMTA) was created as a public entity dependent on SARH's Under-secretariat of Hydraulic Infrastructure (SIH). [61] Finally, in 1989, SARH's SIH was transformed into the National Water Commission (CNA) which, from there on, became the sole water authority of the country. [62] As the CNA also depended on SARH, it became part of this Secretariat while IMTA, in turn, became part of the CNA.

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60 Instituto Mexicano de Tecnología del Agua, (1992), "Informe 1992", IMTA, Jiutepec, Morelos, Mexico

61 Diario Oficial de la Federación, (August 7, 1986), "Decreto por el que se Reforman Varios Artículos del Diverso por el que se Creó el Organismo Técnico Administrativo Denominado Comisión del Plan Nacional Hidráulico", DOF, Mexico City, Mexico, pp. 29-31

62 Diario Oficial de la Federación, (January 16, 1989), "Decreto por el que se Crea la Comisión Nacional del Agua como Organo Administrativo Desconcentrado de la Secretaría de Agricultura y Recursos Hidráulicos", DOF, Mexico City, Mexico, pp. 2-4

But besides public institutions like IMTA, the CNA and SARH, the National Hydraulic System also includes: a) other institutions performing water-related R&D as well as by those providing education and training in areas related to water resources; b) other state agencies with particular interests in the sector; and c) a vast number of direct and indirect water users. In turn, this last group can be divided according to several socioeconomic criteria but for the purpose of this work it will be divided in terms of the final use they give to the water; that is: domestic, commercial, industrial, agricultural, recreational, power generation, etc. Figure IV.2.1 presents a simplified scheme of the Mexican water resources sector emphasizing the position of IMTA and other components of the sector particularly relevant for the development of this work.

As can be seen in Figure IV.2.1 within the industrial sector there is a smaller group formed by those firms generating income from their involvement in the commercialization of products or processes directly related to water technology (e.g. manufacturers of valves, electronic comptrollers, gauges, etc.).[63] In contrast, the relation of the rest of the sector with the SHN is either through the employment of water as a direct input into their production processes and for other general purposes or through the use of water bodies as recipients of industrial wastewaters (IMTA, Nov., 1992).

IV.3 The Mexican Institute of Water Technology and its Mission

As previously mentioned, IMTA was legally established back in 1986 to substitute the CPNH. At that time, the primary objective to justify its creation was: "to develop the technology and qualified human resources necessary to insure the rational and integral use of water in the short and long terms." [64]

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63 Instituto Mexicano de Tecnología del Agua, (November, 1992), "IMTA:Perspectivas de Comercialización de Tecnologías del Agua", Internal Document, IMTA, Jiutepec, Morelos, Mexico

64 Diario Oficial de la Federación, (August 7, 1986), op. cit.

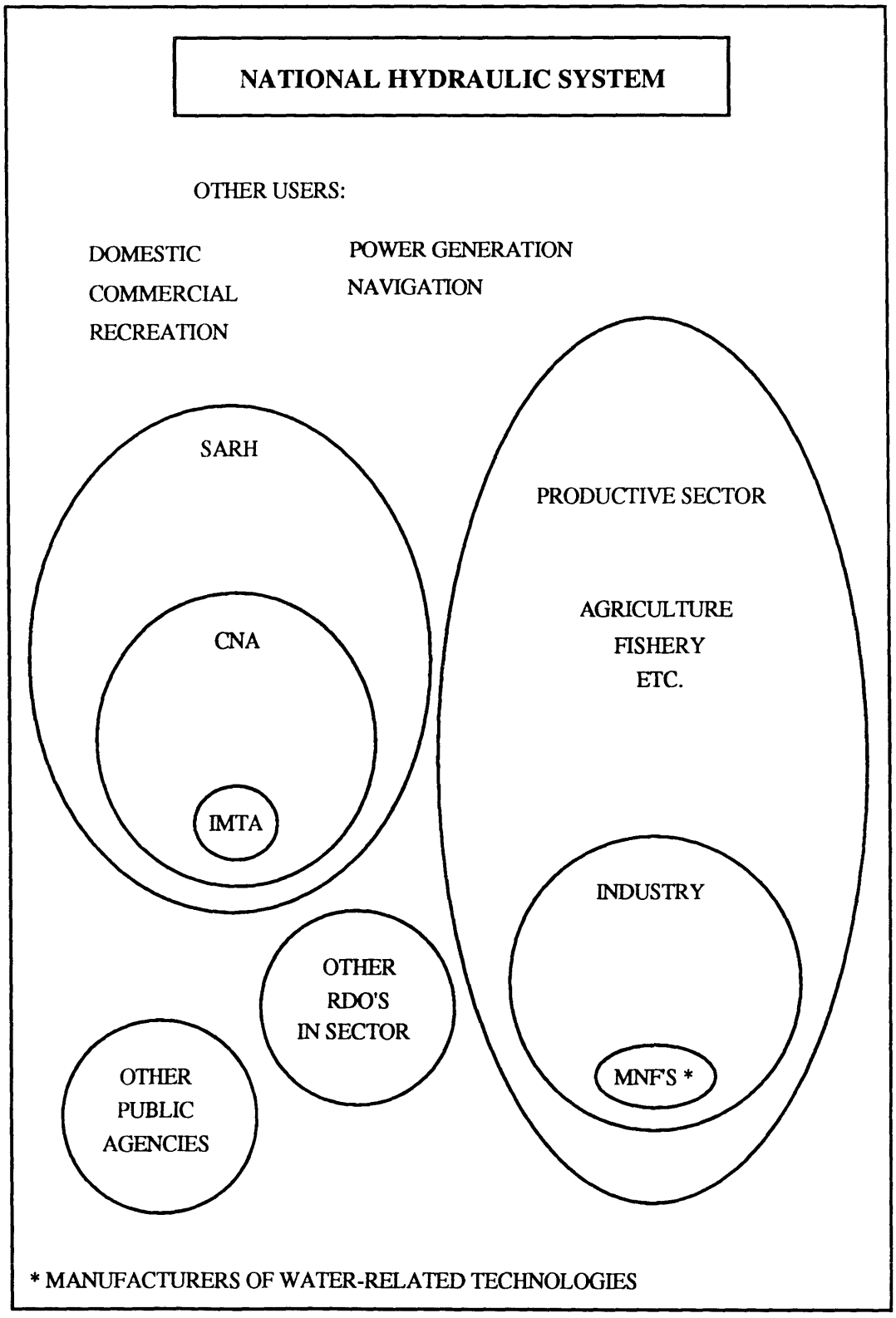

Figure IV.2.1 The Mexican Water Resources Sector

In practice, however, the fulfillment of this objective required IMTA to adopt a much broader mission; that is: a) to strengthen and support basic and applied research for the development and/or adaptation of technologies relevant to the Mexican water resources sector; b) to facilitate the transfer of technology within the hydraulic sector (including aspects concerning the creation, utilization, diffusion, assimilation, adaptation and implantation of this technology); c) to link the R&D efforts and technology transfer activities of the country to the priorities of the National Hydraulic System (SHN); d) to prepare and train the human resources needed to solve the priority problems of the SHN; e) to identify, prioritize, evaluate and distribute among the different sectors of the SHN (e.g. agricultural, urban, industrial, etc.), the country's efforts to perform activities related to R&D, technology transfer and human resources development; and f) to insure that these activities have a positive impact in the economy and society.[65]

As a consequence of undertaking these missions, IMTA has consolidated itself as the main motor for the technological development of the SHN. Therefore, a great part of its activities is directed to set up appropriate conditions to insure that this development is congruent with the possibilities and true needs of Mexico and its SHN. In this sense, IMTA has recognized that an efficient transfer of technology is fundamental to meet these conditions and to achieve a more efficient and rational use of water throughout the country. For this reason, since its creation, IMTA has been actively participating in issues related with technology transfer in the sector. In fact, its involvement in these activities is probably its most important contribution to the development of the country's SHN.

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65 Talavera, A., (December, 1987), "Marco de Desarrollo Tecnológico del Sector Hidráulico Nacional", Internal Document, IMTA, Jiutepec, Morelos, Mexico

IV.4 Organizational Structure

The organizational structure of IMTA has been designed to be congruent with several sub sectors in which the SHN can be divided (see Figure IV.4.1). The maximum authority of the institute is represented by its president (who, at the same time, has to be also the general director of the CNA).[66] Although the president has many internal responsibilities, most of its duties are associated with representing the institute at the CNA and SARH. It is his responsibility to submit to SARH's Secretary the internal regulations. procedures, working programs and budget proposals of the institute for his approval. Similarly, it is his duty to suggest to SARH's Secretary the creation or modification of juridical or administrative instruments that might be useful to improve the efficiency with which the institute carries out its missions as well as to coordinate and promote the utilization of results from the institute in the SHN.

In contrast, the executive provost has responsibilities more directly linked with the internal work of the institute. Besides having to support the work of IMTA's president, he is in charge of technically and administratively managing the institute. Also, he is the official in charge of submitting to the president proposals for the designation of top and middle level civil servants as well as of the direct naming of lower level technical and administrative personnel.

The duties of president and executive provost are supported by an internal auditor as well as by a coordinator of advisors. The internal auditor is mainly responsible for foreseeing that fiscal regulations and procedures are met, while the coordination of advisors was created to advice the institute's authorities in all issues relevant for the institute (lines of research, administrative structures, procedures, etc.).

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66 Diario Oficial de la Federación, (June 7, 1988), "Reglamento Interior del Instituto Mexicano de Tecnología del Agua", DOF, Mexico City, Mexico, pp. 17-20

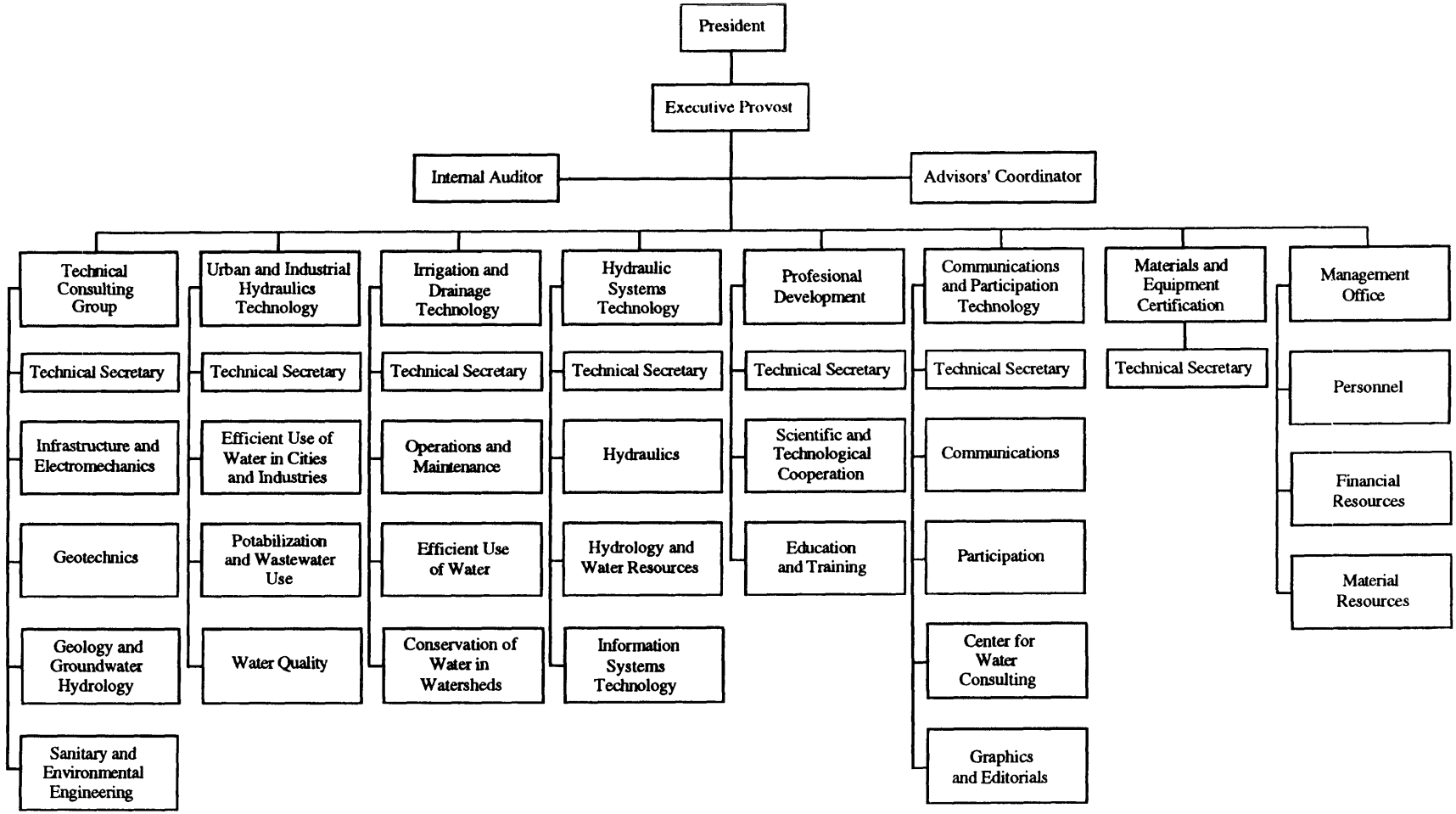

Figure IV.4.1 Organizational Structure of the Mexican Institute of Water Technology (1993)

The rest of the organization is structured around 7 coordinations and 1 administrative office. Each coordination is integrated by 1 coordinator, several sub-coordinators, researchers and administrative personnel. The coordinations are structured around a mixture of functional areas (e.g. professional development), technical fields of expertise (e.g. technical consulting group) and technical and socioeconomic sub sectors (e.g. urban and industrial hydraulics technology). Each has the direct support of a technical secretary and is further on subdivided into several sub-coordinations involved in more specific functions (e.g. education and training) or fields of technical expertise (e.g. potabilization and wastewater use). As for the administrative branch of the institute, the management office is in charge of the general administration of IMTA's human, material and financial resources as well as of the integration of budget proposals.

As can be seen from Figure IV.4.1, IMTA's organizational structure can be characterized as mainly horizontal. However, IMTA as so many other public institutions in Mexico, is really a very hierarchical organization in which the formal distribution of power and authority is always stressed. As a result, internal regulations and procedures are strictly followed and the main flow of information is made through formal communication channels. This is a somewhat undesirable situation because it makes IMTA a very rigid organization. For RDO's like IMTA in which technological innovation and technology transfer activities need to form part of their core competencies, organizational flexibility is of crucial importance. Flexible organization arrangements normally eliminate to a great extent the need to undergo bureaucratic procedures characteristic of many extremely hierarchical institutions. In addition, flexible organizations serve to avoid many of the problems associated with the improper flow of information throughout the organization and between the institute and external firms, agencies or other institutions (e.g. misunderstandings, incorrect information flow , etc.). Therefore, the mere

avoidance of these problems usually makes flexible RDO's better suited to perform their work more efficiently.

Also, the emergence of informal communication networks is usually more difficult in rigid organizations. This is also an important statement because it has been proven that the productivity of the personnel performing activities related with innovation and technology transfer are greatly enhanced through the promotion of informal relationships within their own organization and between this organization and its surroundings.[67] For example, the mere existence of informal relationships inside the institute has the potential to motivate the creativity of researchers as well as their problem-solving capacity if they take advantage of informal consulting with other researchers at the institute. Also, the existence of informal communication networks can significantly ease the flow of information. As in this case information is transmitted more directly and in a highly personal base, the chances for improper transfer are usually smaller. In addition, these networks can significantly contribute to improve the responsiveness of the institute to external needs as well as to the transfer of knowledge from the institute to the SHN because again, the flow of information is more expeditious and information tends to be more accurate. This is an issue that can be quite relevant, especially when response time is an important factor.

IV.5 Activities , Programs and Fields of Research

All the activities and programs related with technological development performed at the institute can be very broadly characterized as falling within the following categories: a) research and development; b) technology transfer; c) consulting; d) human resources development; and e) communication and diffusion of actions.[68] However,

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67 Allen, T.J., (October, 1970), "Communication Networks in R&D Labs.", in R&D Management, A.W. Pearson (Editor), Alden & Mowbray Ltd., Oxford, U.K., vol. 1, no. 1, pp. 14-21

68 Talavera, A., (January, 1989), "Diagnóstico y Consideraciones sobre una Prospectiva Tecnológica del Sector Hidráulico Nacional (Informe Final)", Internal Document, IMTA, Jiutepec, Morelos, Mexico

organizationally these activities fall within the scope of the seven coordinations of the institute.

As can be seen from Figure IV.4.1, activities such as consulting, human resources development and communication and diffusion of actions are each undertaken by one coordination. However, those related with R&D and technology transfer are performed by three coordinations, depending on their field of technical expertise and the socioeconomic sector involved (e.g. urban and industrial hydraulics or irrigation and drainage).

IV.5.1 Research and Development

The research and development activities performed at the institute are grouped at three coordinations (urban and industrial hydraulics technology, irrigation and drainage technology and hydraulic systems technology). As previously mentioned, each of these coordinations is further subdivided into more specific fields of expertise. In this way, specific R&D projects are undertaken by more specialized units. Table IV.5.1.1 shows some of the principal research fields and technological developments that have been performed at the institute.[69]

IV.5.2 Technology Transfer

In a sector such as water resources, technology transfer activities need to be a fundamental component of any strategy for technological development. This is so, because most of the times the final technology users are groups from quite different natures and with very distinct needs and interests (such as peasants, industrialists, etc.). For this reason, it is necessary to insure that the technologies developed in the sector are

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69 Talavera, A., (November, 1988), "Estado Actual de los Principales Elementos del Proceso de Desarrollo Tecnológico del Sector Hidráulico Nacional", Internal Document, IMTA, Jiutepec, Morelos, Mexico

adapted to these needs and that the transfer of technology really takes place (that is, that those technologies are actually assimilated, implanted and utilized by their intended users).

Table IV.5.1.1 Principal Areas of R&D at the Mexican Institute of Water Technology

- Numerical modeling of hydraulic phenomena in areas such as: groundwater hydrology, hydrology, open channel flow, dispersion of pollutants, etc.
- Analysis and simulation of meteorological phenomena (e.g. droughts, storms, etc.)
- Development of schemes for the optimum operation of water resources systems (e.g. for irrigation, water supply, power generation, etc.)
- Development and adaptation of technologies for the efficient use of water at the urban and rural sectors (e.g. lavatory appurtenances)
- Reuse of wastewater for agricultural purposes
- Wastewater treatment
- Pollution control (e.g. biological filters)
- Water quality control

Being aware of the relevance of technology transfer activities in the sector, most of the efforts of the institute are directed precisely towards the design and implementation of technology transfer programs. In fact, IMTA is in charge of running the four larger technology transfer programs currently existing in the SHN. These are (Talavera, Jan., 1989) the: a) Program for the Regional Development of the Humid Tropic (PRODERITH); b) the National Program for the Efficient Use of Hydro-agricultural Infrastructure (PRONEFIH); c) the National Program for the Efficient Use of Water in Cities and Industries (PRONEFA); and d) the National Program for the Reuse of Wastewater (PRONAR).

As for the technologies being transferred, these fall mainly into the following fields: a) planning; b) operations management; c) efficient use of water; d) wastewater reuse; and e) infrastructure and systems safety; and basically include know-how (through training programs) and a wide variety of products and processes (Talavera, Nov., 1988).

IV.5.3 Consulting

Consulting activities in the water resources sector have long been considered extremely important. This is so because many of the problems of the sector are frequently very specific in nature and usually require rapid solutions. For this reason, in 1947, the SRH established the "Technical Consulting Group" (CT). The group (integrated into IMTA since 1986) has long provided support to institutions in the SHN in aspects related to the design of projects as well as in the construction, operation and maintenance of hydraulic infrastructure in the country (Talavera, Nov., 1988). Now that the CT is part of IMTA, its activities have expanded to include consulting in areas related to the adaptation and transfer of technology to achieve a more efficient use and management of hydraulic infrastructure.

IV.5.4 Human Resources Development

The growing demands for water services and the increasing complexity of most of the problems faced by the SHN is emphasizing more than ever the need for having qualified personnel in the sector. Unfortunately, there are still many deficiencies in the country regarding the availability of human resources as well as in the quality of the education and training that they are receiving (especially in the case of technicians and specialists holding graduate degrees). In addition, there are high turnover rates in many of the organizations of the sector because of the low wages normally paid as well as because of the lack of incentives and adequate promotion systems. In order to solve these problems,

IMTA has been working intensively in the education and training of personnel for the sector.

IMTA's activities regarding human resources development are organized around the following programs: training, graduate education, scientific and technological cooperation, information systems and publications.

In the area of training, the institute constantly runs several programs. For example, in 1992, seven courses were offered to more than 5700 people in areas such as maintenance and operation of wastewater treatment plants, efficient use of electric power, management, etc. (IMTA, 1992).

With respect to higher education as of 1992 the institute had granted 162 scholarships (80 foreign and 82 national) in areas such as hydraulics, environmental engineering, management, etc. (IMTA, 1992). In addition, several students are being prepared by IMTA's researchers at the Morelos Campus of the Division of Graduate Studies of the National Autonomous University of Mexico, located within IMTA's facilities. Currently, this division is offering four degrees: Irrigation and Drainage, Water Resources Planning and Management, Hydraulics and Potable Water; and Sanitation and Pollution. In 1992, thirty two students were enrolled in these programs (IMTA, 1992).

As for technical cooperation, in 1992, IMTA participated in 48 agreements with national institutions (85% with higher education institutions and 15% with other organizations in the sector (IMTA, 1992)). In the international arena, it established agreements with 17 institutions from 9 countries (US, Spain, France, Japan, Egypt, Israel, Canada, UK and Germany). In addition, in that year negotiations started to establish cooperation programs with organizations in countries like Argentina, Brazil, Chile, Dominican Republic,

Panama and Venezuela, as well as with international organizations such as the World Health Organization and the Pan-American Health Organization (IMTA, 1992). Besides, the institute actively participates in technical visits, national and international seminars, conferences and symposia. As a result of this participation, organization from several countries have expressed their desire to establish cooperation programs with the institute.

IV.5.5 Communication and Diffusion of Actions

The most important contribution of the institute in this area is definitely related to its participation in the handling of information relevant to the SHN. Since its creation, IMTA has been working extensively in this field, generating information networks and establishing services for the handling of information to make it available throughout the country. After the foundation of the Center for Water Consulting (CENCA), IMTA consolidated itself as the main receptor, administrator and diffuser of information in the country (IMTA, 1992). In particular, its participation in this area has been extremely important to integrate upcoming information for the CNA and SARH (e.g. data collected from gauging stations scattered throughout the country).

In terms of publications, the institute publishes a journal specialized in hydraulics, brochures of upcoming national and international events relevant for the water resources sector and a catalogue of periodicals received by the institute. In addition, IMTA also publishes each year several manuals and technical documents derived from the work of its researchers (IMTA, 1992).

IV.6 Resources

Eight years after its official foundation, IMTA has consolidated itself as an important motor for the technological development of the SHN. Undoubtedly, this fact can be attributed to a great extent to the quality of its human and material resources base as well

as to its relatively stable financial position; all of which have provided IMTA with the capabilities necessary to carry out its missions.

IV.6.1 Human Resources

Since its foundation, IMTA has always enjoyed an good reputation among the institutions and organizations conforming the Mexican SHN. In fact, the prestige of the institution is even starting to cross national borders to gain the recognition of important organizations in other countries. There is no doubt that this reputation is largely the result of the qualifications and excellence of the human resources of the institute; in particular, of a good part of its research staff. Through the years, the institute has managed to recruit some of the best expertise in the Mexican water resources sectors from universities, government agencies and private organizations. Many of these researchers are professionals with solid academic backgrounds, vast experience and a deep knowledge not only of their own technical fields but also of the entire problematic of the SHN.

Back in 1992, IMTA had 449 employees distributed in the following way (IMTA, 1992): 30 managers, 269 specialists in hydraulics and related fields of expertise, 84 technicians and 66 management assistants. From the 269 specialists, 115 held graduate degrees (4 with specialization, 88 with masters and 23 with Ph.D.'s) and 27 are members of the National Researchers System (SNI).

In order to continuously enhance the qualifications of its personnel, the institute has established permanent training programs to keep them prepared and up-to-date in areas such as information systems, project management and communications. Besides, IMTA has been actively supporting candidates for graduate education and continuous education programs. As mentioned before, this is being done either through the provision of

scholarships to study in Mexico or in other countries or through the direct education of students at UNAM's Division of Graduate Studies located within IMTA's facilities.

IV.6.2 Financial Resources

Since its creation and until 1989, the operational budget of IMTA came entirely from the federal government in the form of a direct subsidy. However, starting in that year, and coinciding with the creation of the CNA, IMTA began to obtain part of its financial resources through contracts with other institutions. In 1989, 14% of its operational budget came from contracts with the CNA while in 1990 this percentage grew to 36.5% and one year later to 55%. Therefore, by 1992, from the institute's budget of $34 million, $18.7 million came from the CNA and $15.3 million came from the federal government (IMTA, 1992).

As can be seen in Figure IV.6.2.1, which shows the evolution of the operational budget of the institute since its foundation, the total financial resources provided to the institute during its first five years of operation remained relatively constant in this period. However, starting in 1991 these resources significantly increased as a result of the contracting of projects with the CNA. Even though, the difficult economic situation of the country and in particular of the SHN, is starting to reverse this tendency. This is not to say that the contracting of projects with the CNA is becoming less important but rather that the overall amount of funds received by the institute is getting smaller (obtained both from contracts with the CNA and from direct federal subsidies).

IV.6.3 Material Resources

IMTA is regarded as having some of the finest facilities in the country (and in Latin America) to perform research in the water resources sector. Eight years after its creation,

most of the original plans for the construction and equipment of laboratories are now completed. Some of the main research facilities currently operating at the institute

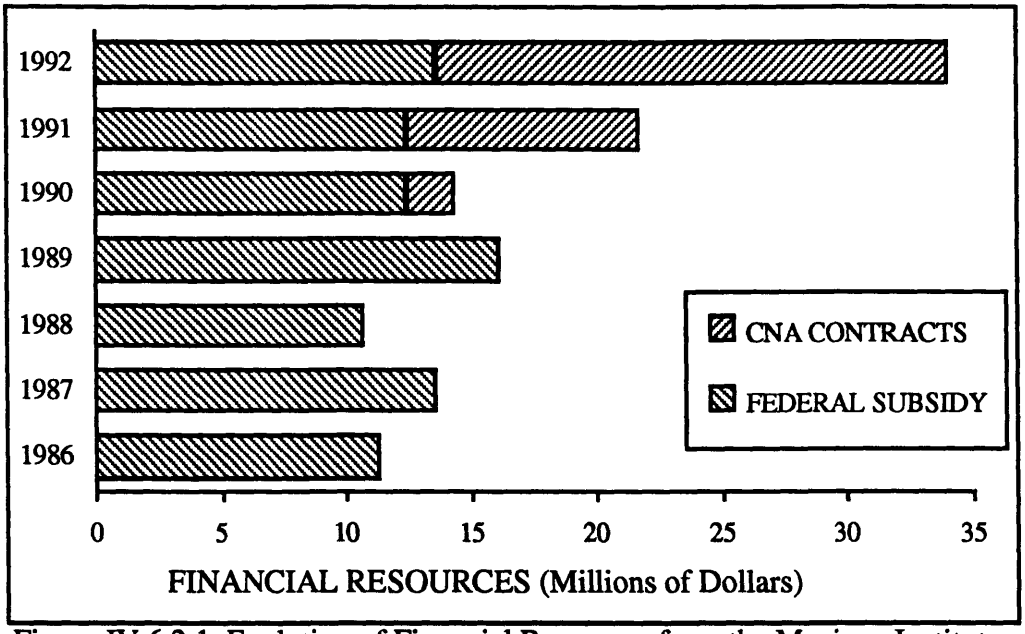

Figure IV.6.2.1 Evolution of Financial Resources from the Mexican Institute of Water Technology [70]

include a water quality control laboratory (LCA), the IMTALAB, and a series of external models to simulate the operation of important water resources projects. The water quality control laboratory is now fully equipped to allow the determination of the physical, chemical, biological and microbiological parameters of water and is now being extensively used in studies related with wastewater treatment, wastewater reuse, and diagnosis of water quality, among others (IMTA, 1992). As for the IMTALAB, this research facility is mainly employed to perform studies regarding the efficient use of water, metering and certification of equipment (e.g. valves, lavatory appurtenances, gauges, etc.).

[70] IMTA, (1992), op. cit.

With regard to information systems, IMTA has completed the integration of a single computer network throughout the institute and has proceeded to the modernization of a large part of its computer equipment. Also, IMTA has now access to important computer resources from other institutions such as UNAM and is currently integrated into the telecommunication network of the CNA (IMTA, 1992). Additional information systems resources include a wide variety of specialized software packages as well as a large library that receives, among others, more than 250 periodic journals related to the water resources sector (IMTA, 1992).

Chapter Five: Policy Analysis of Alternatives to Link the Mexican Institute of Water Technology with the Industrial Sector

V.1 Introduction

The purpose of this chapter is to analyze from a policy perspective IMTA's decision to pursue a development strategy that explicitly stresses the need for the institute to collaborate more actively with the productive sector. Therefore, the analysis will be helpful to understand why is the institute trying to implement programs to strengthen its ties with industry; to look at the possible options that the institute might have and their implications and finally, to identify the resources needed to implement the policy.

The policy analysis presented here is based on the analytic framework developed by Grindle and Thomas (1991) to explain policy choice (see Figure V.1.1).[71] The reasoning behind this decision is that the conceptual base of their analytic framework seem to be adequate to explain how public policy-making is done in countries like Mexico: first, because policy choices are mainly the result of activities that take place largely within the state; second, because those choices are significantly shaped by policy elites who bring into policy-making their own perceptions, commitments and resources to bear on the content of reform initiatives; and third, because the decisions of policy elites are influenced by the perceived or actual power of societal groups and interests that have a stake in reform outcomes (Grindle & Thomas, 1991).

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71 Grindle, M., & Thomas, J., (1991), "Public Choices and Policy Change, The Political Economy of Reform in Developing Countries", John Hopkins University Press, Baltimore, Maryland, U.S.

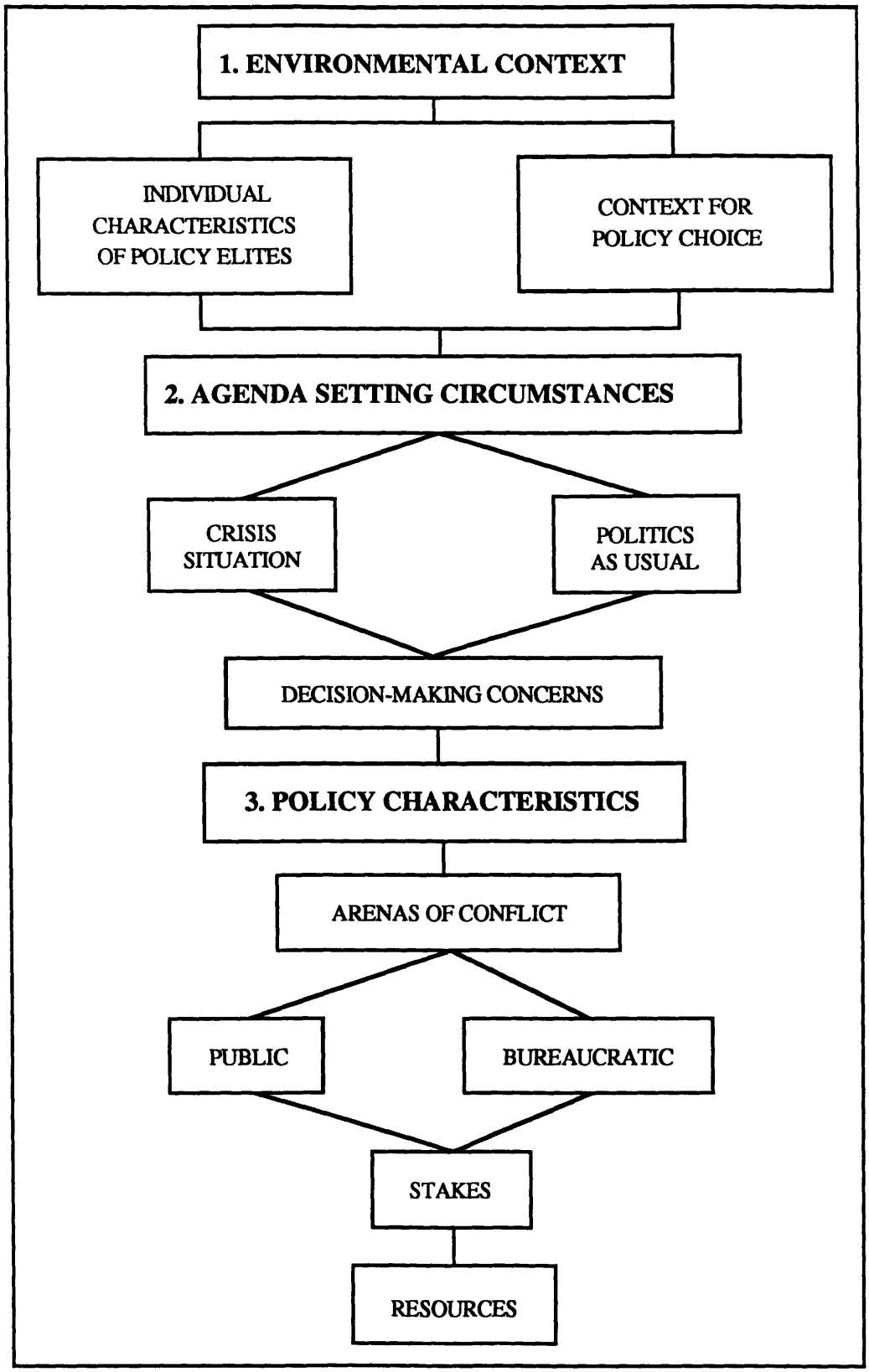

Figure V.1.1 Framework for Policy Analysis
Source: Adapted from Grindle & Thomas, (1991), op. cit.

V.2 Environmental Context

The first step required to analyze IMTA's decision to pursue a strategy that stresses the need for a more active cooperation of the institute with the productive sector is necessarily to understand the reasoning behind this decision. In order to do so, it is crucial to analyze first of all, the environmental context surrounding such decision. As seen in Figure V.1.1, this environment depends both in the context for policy choice and in the individual characteristics of the institute's policy elites.

V.2.1 Context for Policy Choice

Undoubtedly, the mere fact that IMTA is directly or indirectly part of the National System for Science and Technology (SINCYT), makes the institute, in one way or another susceptible of being affected by the structural conditions of this system. Therefore, it is important to recognize that the economic, political, social and technical conditions discussed in Chapter Three, will also influence any attempt of the institute to implement programs to strengthen its ties with the industrial sector. As these conditions were extensively explained in the analysis of the phenomena of RDO's - Industry interaction in Mexico, they will not be included again in this chapter. Rather, this section will present those conditions and policies that have a more direct impact on the SHN and on the activities of the institute.

V.2.1.1 Economic Conditions

As previously mentioned, the mere fact that IMTA is an institution immersed in the SINCYT makes it subject to the structural conditions of the system. In particular, the reduction in public expenditure in science and technology matters has had a profound impact on IMTA. This is not to say that budget cuts have been such that the institute has been forced to cancel important projects, shrink research programs or layoff personnel. But even though this is not the case, there seems to be a widespread opinion at the

institute that small budget cuts and even stagnant budgets are unacceptable (especially among top level officials). If the institute is to be able to deal with the increasingly challenging problems and with the growing demands of the SHN, its financial resources will also need to be constantly growing.

The reduction in public expenditure has affected the institute through two channels. First, in the form of direct cuts from the federal subsidies provided to the institute. And second, through the reduction of operational budgets granted to SARH and the CNA (as both represent the main "customers" of the institute).

It is important to note that even though the establishment of contract agreements with SARH and the CNA has reduced IMTA's dependence on direct subsidies from the federal government, this conditions has really not made the institute financially less vulnerable. As mentioned in Chapter Four, contract agreements with the CNA provided 55% of IMTA's budget in 1992 while direct subsidies from the federal government provided for the other 45% (IMTA, 1992). As can be seen, IMTA's dependence on both the CNA and the federal government is still too large.

In order to have access to financial resources to: a) compensate for budget cuts; b) generate additional income to expand its activities; and c) reduce IMTA's financial dependence and vulnerability, the institute has been trying to diversify its funding sources. This means that IMTA wants to start capturing part of its income from organizations other that SARH and the CNA. As industry is often regarded as an important source of funds, it is understandable to consider it a potential customer for IMTA; especially, because it is perceived that the institute can offer products, processes and services of great value to the industrial sector.

V.2.1.2 Societal Pressure

As mentioned in the previous chapter, the Mexican SHN is currently facing the challenge of dealing simultaneously with many complex problems: growing demand for services, increasing pollution of water resources, water scarcity, stricter demands for water of a better quality, etc. These problems are complicated even more by the fact that their solution often has to deal not only with technical difficulties but also with a series of political, social and even legal conflicts. As a result, institutions working in the SHN are finding it increasingly difficult to satisfy the needs of the population, particularly because the solution of these complicated problems often requires large investments and financial resources are limited. In addition, quite often there is limited time to solve these problems and therefore, solutions usually need to be found rather quickly.

On the other hand, due to the vital importance of water, it is probably one of the sectors in which the population often exercises more pressure over authorities to satisfy their demands. Most of the times, this pressure comes from groups of individuals organized to demand solutions to their problems (e.g. peasants), but even in the case when societal groups fail to organize themselves, they seem to be able to exercise some kind of pressure over the government. This last statement seems to be especially applicable when the demands come from influential sectors (e.g. industry) and powerful elites that can exercise considerable pressure over the government to solve their problems.

The coupling of the problems faced by the SHN and societal pressures is forcing institutions in the SHN to find more appropriate ways to deal simultaneously with these challenges. For an institute like IMTA, a more active interaction with the productive sector can certainly push the institute in the right direction as it can serve to improve the responsiveness of the institute to the demands of an important group of the SHN. If

IMTA is better suited to identify the true needs of the sector it will certainly be in a better position to develop technologies of a broader and deeper impact on society.

V.2.1.3 Administrative Capacity

This area probably represents the one in which the institute is less prepared to deal efficiently with the challenge of interacting with industry. There are no specific organizational structures set in place for the management of technology; there are still no organizational units explicitly designed to handle the possible interaction with industry; the efforts for improving the interaction with organizations other than SARH and the CNA are scattered across the different coordinations of the institute; there seems to be a lack of communication and exchange of ideas between the parties involved in these efforts; and there is a lack of internal regulations and procedures needed to handle the interaction. In summary, there is a need to institutionalize IMTA's efforts regarding the interaction.

In addition, although the institute has considerable expertise in a variety of managerial and technical fields, they require personnel trained in areas such as management of technology. Also, they need to recruit professionals with some knowledge of certain legal aspects related for example, with intellectual property protection, formulation of contracts, etc. Until now, most of the efforts related with technology management have been directly undertaken by the different coordinations of the institute. However, their productivity could increase through the guidance and advice of professionals better trained in these fields.

All of the issues previously described can be extremely important not only for the design of specific interaction programs but also because they can affect the ability of the institute to successfully implement and sustain such programs.

V.2.1.4 The New National Water Law, 1992

In December 1st, 1992, the Official Diary of the Federation published the new National Water Law (LAN).[72] Among its most important provisions, the New Law consolidated the CNA as the sole executive authority in water-related issues in the country. In addition, the LAN established the creation of a Public Register for Water Rights (REPDA) to exercise a better control over water resources and its uses. But most importantly, the new Law now permits the direct participation of the private sector in the construction and operation of hydraulic infrastructure. For a country like Mexico this is a relevant decision because before the enactment of the LAN, all the hydraulic infrastructure of the country was owned and operated exclusively by the state.

Undoubtedly, the privatization of hydraulic infrastructure in the SHN has the potential of opening important windows for cooperation of an institution like IMTA with the private sector. The lack of experience of many of the firms that will enter in the sector can certainly mean a demand for the technologies, expertise and technical assistance that IMTA can offer. Therefore, it is reasonable to expect that in the near future demands for the products and services offered by the institute will tend to increase.

V.2.2 Characteristics of Policy Elites

Besides the contextual factors previously described, there is another set of factors that can be extremely important to understand why is the institute trying to improve its links with the productive sector. But rather than dealing with IMTA as an institution, these factors deal with individuals, with the policy elites and the actual decision-makers responsible for the formulation of policies at the institute. In the specific case of IMTA, these policy elites are mainly formed by a group of top level officials from the institute

72 Diario Oficial de la Federación, (December 1st, 1992), "Ley de Aguas Nacionales", DOF, Mexico City, Mexico, pp. 22-44

itself such as its president, executive provost and several advisors. Although it is obviously very difficult to generalize upon this issue, it seems that the policy elites of the institute have some of the following characteristics.

V.2.2.1 Personal Propensities and Goals

It is important to consider the personal propensities and goals of policy elites in policy analysis because they can help to predict the aggressiveness with which solutions may be sought and how much change may be considered appropriate (Grindle & Thomas, 1991). In a bureaucratic institution like IMTA it is frequent to observe how policy-makers tend to approach problems from a rather conservative position. It is rare to observe drastic organizational changes or significant shifts in policy. Moreover, even in the cases where changes like these are necessary, it seems that there is not much propensity among IMTA's policy-makers to seek for consensus because: a) changes are normally implemented through rather long time frames and this tends to reduce resistance; and b) the considerable concentration of power fosters a tendency to impose decisions.

In the case of IMTA the decision to diversify its funding sources came from top level officials within the SHN and from the institute itself. As it will be explained later on, this characteristic may be an instrumental factor to enhance the chances for success of the policy.

V.2.2.2 Ideological Predispositions

A significant part of the personnel working at the institute and in particular its policy elites believe that IMTA should play a more active role in the solution of the technical problems embedded in the SHN. This means that according to them the institute should have a greater participation in the satisfaction of societal needs related with water

resources. This could explain their apparent desire to expand the presence, relevance and prestige of the institute not only within the SHN but also within other sectors.

Also, it seems that the institute is emphasizing the role that technology should play in the development of the SHN. This situation might be a reflex of the generalized belief in many developing countries that technology is the sole solution of many of their problems. In the case of the SHN it seems to be taken for granted that technology and modernization are the correct means to achieve a more efficient and rational use of water.

Finally, there is also a predisposition to think that the appropriate solution to the problems of the SHN requires an active participation of all the socioeconomic sectors of country. This means that the search for appropriate solutions requires inputs and active cooperation from government, industry, workers, peasants and society at large. For this reasons, organizations in the sector place a great importance to the participation and contribution of society to the solution of the SHN's problems.

V.2.2.3 Professional Expertise and Training

Since IMTA is an institution deeply involved with R&D and consulting activities, a significant part of its personnel has a technical background. Not only its researchers but many of its managers hold engineering degrees, which indicates a strong commitment to technology. Moreover, many obtained their degrees in countries in which industry frequently plays a very important role in the creation, diffusion and commercialization of products and processes derived from scientific and technological knowledge. All of these factors seem to set the appropriate field for the development of predispositions such as the ones previously mentioned: technical solutions to problems are frequently stressed, the role of technology in the development of the sector is emphasized and sometimes there is a tendency to try to import solutions to national problems from other

countries (unfortunately quite often without taking care of making the necessary adjustments).

V.2.2.4 Previous Experiences

Although the experience of the institute regarding the solution of problems similar to this one is rather limited, it seems that one thing is clear. There are many deficiencies in the way the institute is operating and therefore there is still much room for improvement. In addition, it is important to note that there are several organizations in Mexico somewhat similar to IMTA, that have succeeded to diversify their funding sources and to establish a more active cooperation with industry. Undoubtedly, IMTA's policy elites are aware of these cases and might try to look at them to learn from their experiences.

V.2.2.5 Position and Power Resources

IMTA is currently giving a high priority to the issue of diversification of funding sources. As mentioned before, the top level political support for the policy reform can be extremely important because of several reasons: first, it can ease the acceptance of reform by the institute's personnel; second, it can provide a high hierarchy to the reform in the eyes of other organizations (particularly SARH and CNA); and third, it might increase the chances for success of the reform because it guarantees to a certain extent the resources and support that are needed.

V.2.2.6 Political and Institutional Commitments and Loyalties

The institute and its personnel can both be characterized as being firmly committed to the fulfillment of the missions for which the institute was created. They seem to be loyal to the institute, to the CNA and SARH as well. This is especially true in the case of top level managers and some senior researchers as they normally keep personal loyalties to many other top level officials from organizations such as these. Institutions like IMTA

are still very paternalistic and therefore patronage relationships always tend to prevail in them (although because of the technical extraction of most of its employees this is not as clear as in other public organizations). After all, it has to be remembered that IMTA's president, the executive provost and most of its top and middle-level managers are appointed directly by other top level officials.

On the other hand, the juridical status of the institute has created a relation of dependence of the institute with the CNA and SARH that is not only making IMTA financially vulnerable but that is also limiting IMTA's capacity to perform its responsibilities efficiently. For example, the close relation of the institute with the CNA sometimes gives rise to excessive bureaucratic procedures that reduce the efficiency with which the institute performs its missions (higher costs, time delays, etc.).

This situation is creating a conflict between the desire to make IMTA a more independent organization and the compromises held by some top level managers with high-ranking officials of the CNA and SARH that are opposing the reform. After all, it is understandable that the CNA does not want to loose its influence over IMTA as the institute is practically the only technical branch of both CNA and SARH.

V.3 Agenda Setting Circumstances

After identifying the context surrounding policy-making and the characteristics of policy elites, the basic stage is set to understand the initiatives for reform. Now, it is necessary to analyze the circumstances that brought the problem into IMTA's agenda.

V.3.1 Politics-as-Usual Circumstances

According to Grindle and Thomas (1991), policy reform is influenced by circumstances that drive particular issues into policy agendas. That is, if policy changes are "crisis-

ridden" or if they are the product of what they term "politics-as-usual" circumstances. Contrary to what seems at first glance, the institute's decision to look for alternative sources of income corresponds to a "politics-as-usual" type of situation, even though the country was immersed in an economic crisis when this issue first came into IMTA's agenda.

The reasoning behind this assertion is as follows: First, the institute really never had to confront significant budget cuts due to the reduction of federal subsidies and moreover, starting in 1990, even these cuts were compensated by the income generated from projects contracted with the CNA.

Second, although the federal government pressured the institute to start capturing income from organizations other than the CNA and SARH, this pressure still came from inside the government and not from external actors as in many crisis-ridden reforms. This is not meant to imply that pressures were not important but rather than IMTA's managers must have had certain latitude to decide whether or not to push for policy reform and institutional change.

Third, the stakes at stand in IMTA's policy reform are clearly embedded in the bureaucratic arena and, in particular, within the institute's bureaucracy. The changes in organizational arrangements. shifts in power relationships, modification of procedures and the establishment of new programs with institutions other than the CNA might create internal conflicts and resistance to change, especially among researchers. Although obviously all of them are important factors to consider, they are not comparable with issues such as political stability, often encountered in crisis-ridden reforms. Clientilistic and paternalistic relationships may be at stake, but the institution as such is not.

Fourth, in contrast with crisis-ridden reforms, policy-making and the development of strategies to deal with the problem faced by IMTA was done by middle-level officials. However, it has to be remembered that the initial directive for reform came from top management and, moreover, that because of the extreme hierarchization of the institute, the approval from top officials is always indispensable.

Fifth, under non-crisis conditions such as the ones described here, there is frequently enough latitude to implement changes incrementally. This situation has some advantages and disadvantages. On the one hand, it allows for the reduction of opposition to reform because changes are gradual and this allows people to adapt more easily to changes and also because it allows for policy adjustments to be made along the way therefore improving the effectiveness of the policy. However, on the other hand, this condition is often the cause of significant delays in the implementation of policy reform because when more important issues arise it forces the reform to be temporarily left aside (as has happened with IMTA because after several years the institute has not been able to implement the policy; the institute still seems to be working in building up their own capabilities for the reform).

And finally, the fact that this policy reform is non crisis-ridden has given IMTA flexibility in the timing to push for its implementation. Therefore, the institute has pushed for reform when conditions are appropriate (for example, after the enactment of the New National Water Law) and leave it aside when they are not (e.g. when CNA is pressuring to stop its implementation).

V.3.2 Decision-Makers Concerns

Besides the analysis of those conditions that influence policy contents, it is necessary to analyze how the decisions to implement or reject such policy are made. In order to do so,

it is important to understand what are the specific concerns of policy elites and more importantly, of decision-makers.

Due to the nature of both the institute and the policy reform under consideration it is logical to expect policy-makers to be mainly concerned in this case with two issues: the "technical correctness" of the proposed reform and the bureaucratic implications of its implementation.

As mentioned before, organizations like IMTA in which science and technology play such an important role usually develop a mentality in which the technical aspects of problems and their solutions are often stressed. As a result, it is not uncommon to observe how policy-makers try to judge the implications of a particular policy merely based on their technical content. The reasoning behind this behavior might be that the "technical correctness" of a particular policy is used to justify decisions, especially when the policies tend to be unpopular (Grindle & Thomas, 1991). However, and despite its obvious limitations, this issue of "technical correctness" is still a powerful tool. For example, in the case of IMTA, the institute can argue that its proposal for greater independence is congruent with current public policy trends favoring economic liberalization, open market economies and public austerity pursued by the federal government.

On the other hand, the implementation of the policies proposed by IMTA imply changes in the bureaucratic structure of the institute. For this reason, it might be valid to think that decision-making is dominated by bureaucratic concerns. Under these circumstances, issues like administrative capacity, budgets, compliance and responsiveness are of great importance. Factors such as rivalries, competencies and organizational morale may also bear the minds of the decision-makers. After all, it has to be taken into account that it is

most likely that many employees will present some opposition to change. People usually feel comfortable working in environments that provide them a sense of certainty and stability; but change almost by definition always implies uncertainty and lack of stability, at least temporarily.[73] The way in which change affect power relationships, career options, labor conditions, etc., may influence the response of bureaucracy to policy reform and therefore policy elites quite probably bear these factors in mind while making decisions. So too, are issues related to the establishment of incentives intended to modify bureaucratic behavior and procedures as well as other considerations like, for example, the status, position and power of the institute within the government.

While "technical correctness" and bureaucratic implications may be the most obvious concerns of policy makers at the institute, there is a third factor that is very important. That is, the ability of IMTA's top management to earn support for the reform from other top levels officials in the government and from other organizations. Particularly important may be the support of SARH's secretary or from other Secretaries at Ministries such as Finance, who might back up the policy if it can be justified, for example, in terms of economic efficiency.

V.4 Policy Characteristics and Policy Implementation

While the whole processes of policy and decision-making are normally characterized as being fairly complex, quite often the implementation stage is even more complex. Despite its importance, however, there is a tendency among many policy-makers to ignore or to give inadequate attention to the issue of implementation while formulating a policy (Grindle & Thomas, 1991). Perhaps they chose to do so because of the complexity involved, or perhaps they just fail to consider it a component of policy-

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[73] Nadler, A. D., (1988), "Concepts for the Management of Organizational Change", in Readings in the Management of Innovation, M. Tushman & W. Moore (Editors), Harper Business, New York, New York, U.S., pp. 718-731

making; but whatever might be the case, they just seem to take for granted that once a policy is formulated and the decision to go ahead is made, that such policy will be implemented as planned. Unfortunately, this belief often proves to be wrong. Sometimes is even more important to look beyond a certain decision to question whether the proposed policy has a reasonable chance for being implemented (Grindle & Thomas, 1991). For these reasons, policy-makers need to explicitly take into account this issue during the policy analysis and to design specific strategies for the implementation stage of the policy. In order to do so, first it is necessary to analyze the problems associated with the implementation stage. This implies looking at the potential arenas of conflict, stakes and available or required resources for the implementation.

V.4.1 Arenas of Conflict

The specific characteristics and contents of policies are largely responsible for determining the type of conflicts and opposition that surround their implementation (Grindle & Thomas, 1991). As mentioned before, in this case IMTA might expect to encounter mainly internal opposition for the reform from the institute's bureaucracy. However, the final outcome of the policy reform might as well depend on how other agencies or public officials outside the organization, react to this reform. But even if this is the case, it is important to note that the concerns for the reform still remain embedded within the government and not within the general public.

V.4.2 Stakes

Because the arenas of conflict reside mainly within the government, the economic and political benefits and costs derived from the implementation of the policy will also be borne by the state, at least in the short term. Although in the long term the public might benefit from IMTA's improved operating efficiency, initially the costs will be borne by the officials and institutions affected by the reform. Top level officials might see their

clientilistic and patronage relationships altered; coordinations used to handle certain problems may be affected by the shift in functions to other units; institutions might see their visibility, prestige, power or position within the government changed, etc.

From all this, it can be observed that the political stakes are relatively low. Therefore, the real issue is to determine if IMTA has enough capacity to implement the reform and whether the institute can generate enough support to make the bureaucracy comply with the reform.

V.4.3 Resources

The previous subsections were useful to determine the potential reactions to the proposed policy as well as the prospects for sustaining the reform. It is now necessary to assess whether IMTA has the resources required to implement the policy or if these resources need to be augmented. The most important resources that the institute will require fall into the following groups: political, financial, managerial and technical.

V.4.3.1 Political Resources

As mentioned before, the feasibility of a successful implementation of the reform will depend largely on the capacity of IMTA's top level official to earn the political support of other agencies and powerful actors. This is particularly important because it has to be remembered that there are certain interests in the CNA that might oppose the reform. After all, IMTA is the technical branch of the CNA and for this reason, the Commission might not be willing to let IMTA become too independent from them. In a sense, they need to maintain the institute captive to make sure that its lines of research, projects, etc., are congruent with their own needs and/or strategy. As mentioned before, the support from SARH's Secretary as well as from other ministries might be a fundamental backup to overcome resistance from the SHN.

Similarly, this level of political support can also be helpful to overcome internal resistance. Top level support provides a certain degree of hierarchy or relevance to the policy. For a bureaucratic organization like IMTA, this issue can be a very influential factor to insure compliance.

V.4.3.2 Financial Resources

Due to the nature of the policy under consideration, financial resources do not seem to represent a problem in this case. Most of the changes implied by the reform will consist mainly of organizational rearrangements. Most likely, it will be possible to deal with this changes with the operational resources of IMTA (with the probable exception of certain personnel and professional expertise that the institute might need to recruit).

V.4.3.3 Managerial Resources

Although a good part of the changes proposed can be performed by existing personnel and expertise it may be necessary to contract some people; especially some managers with experience in technology management. The new organizational arrangements that will be needed may not only imply new managers but quite probably new management styles and mentalities as well. This is an important issue to consider because it will influence even more the power relationships already affected by the organizational changes.

V.4.3.4 Technical Resources

The availability of technical resources is closely linked to the skills and expertise of the institute. As IMTA already has considerable expertise in technical fields related with water resources, again its main concerns should be the contracting of personnel with

experience in technology management as well as with some legal expertise in areas such as technology licensing.

V.5 Policy Content

The content of the specific policy that the institute chooses to implement will depend on the interaction of the three set of factors described in the previous sections. The broad orientations and perceptions of policy elites, the contextual factors that help shape those orientations, and the circumstances surrounding reform initiatives, all interact to determine this content. Similarly, the specific concerns of policy-makers coupled with an assessment of the resources available and those that would be required to implement the policy would also have a deep impact in the policy content.

In the case of IMTA, it seems that at the end, everything came together and pointed out in the same direction. More external contracting and larger involvement of IMTA with the productive sector. Figure V.5.1 summarizes the policy analysis for the institute.

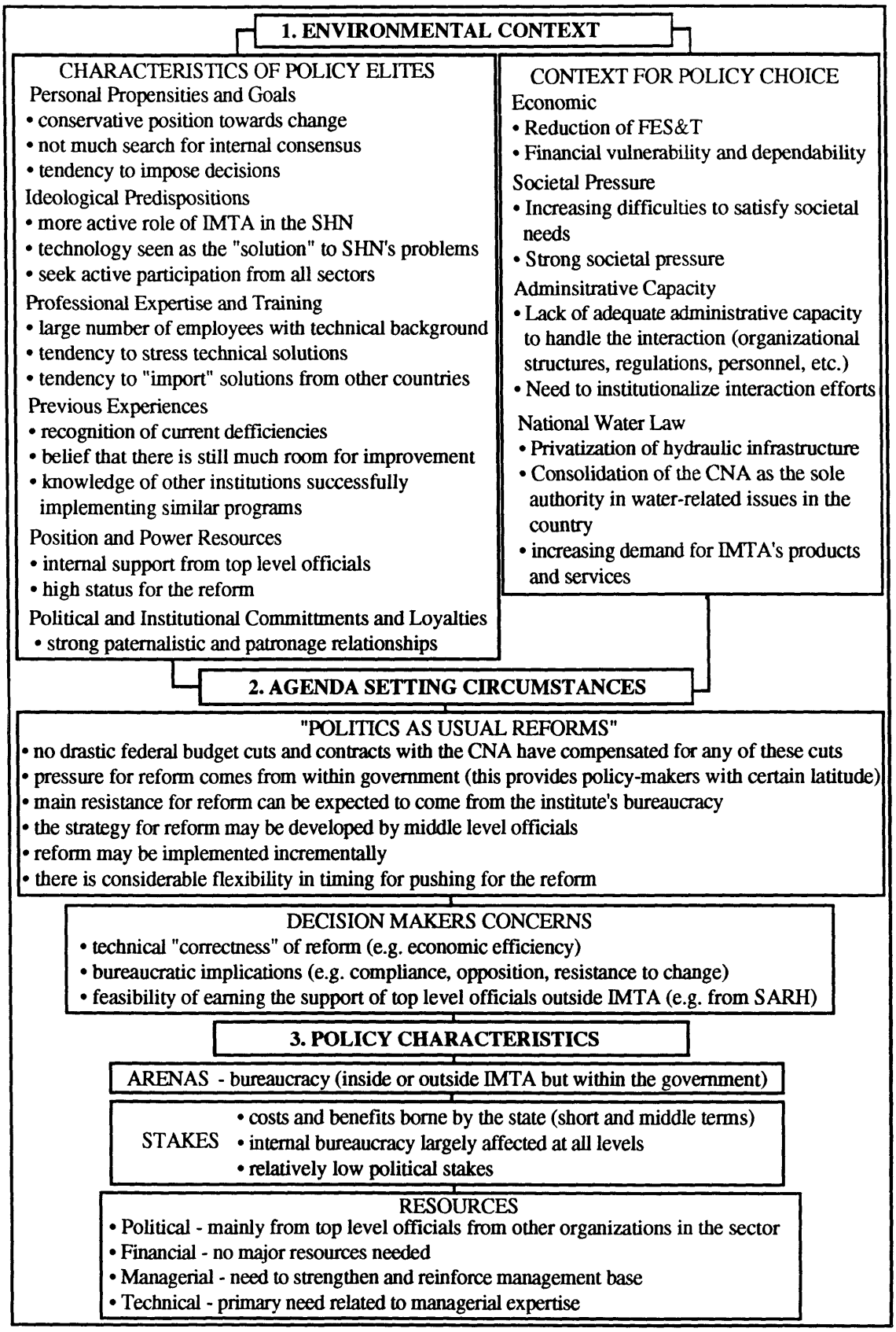

Figure V.5.1 Application of Policy Framework to Analyze the Case of IMTA

Chapter Six: Strategy for Linking the Mexican Institute of Water Technology with the Productive Sector

VI.1 Introduction

Throughout the preceding chapters, this work has gone from a general overview of the process of RDO's - Industry interaction to a policy analysis of the causes that are leading a particular RDO to establish programs to interact with the industrial sector. The insights gained from the presentation made in Chapters Two and Three allowed for a good understanding of the problems associated with the interaction as well as for a better comprehension of the structural, procedural and individual factors that may influence the interaction in the particular case of Mexico. Chapter Four made a presentation of the Mexican Institute of Water Technology, to allow for an understanding of its mission, organizational structure, activities, programs, regulations, procedures, personnel and culture. Chapter Five included a policy analysis to explain why is the institute interested in the implementation of programs to link IMTA with the productive sector as well as to explain the role that these programs will play within a more general development strategy of the institute. It is now the purpose of this chapter to bring everything together and develop a linkage strategy for the institute. Therefore, the strategy will necessarily have to take into account: the specific objectives pursued by the interaction; the general problems endemic to the establishment of cooperation programs as well as those derived from the particular situation of IMTA; the capabilities of the institute and the demands from industry; and finally, the resources that IMTA has to obtain to successfully implement the policy.

VI.2 Definition of Objectives

One can never seem to sufficiently stress the importance of clearly defining the objectives pursued prior to the design and implementation of any program or policy reform. For the particular case under consideration several objectives were identified to justify the decision to implement programs to link IMTA with the industrial sector. However, it is important to point out that their relative importance may vary and therefore, it is difficult to affirm which one wins over the other. This is particularly true because while some of the objectives are explicitly stated, others seem to be implicitly considered by IMTA's policy-makers (although this does not necessarily mean that they are less important). Table VI.2.1 shows the main objectives identified.

Table VI.2.1 Main Objectives for Implementing Programs to Link IMTA with the Industrial Sector

- To generate additional income for the institute and its personnel (especially for researchers), so that they can function as incentives to improve their creativity, willingness to innovate and productivity
- To reduce the financial vulnerability of the institute through the diversification of funding sources
- To reduce the dependence of the institute on the CNA as a means to improve the efficiency with which the institute performs its missions
- To identify and respond more efficiently to the needs of an important component of the SHN (the productive sector), ultimately in the benefit of the whole sector and society at large

As can be concluded from the presentation made in Chapter Two, there are obviously many other advantages or benefits that can be cited to justify the policy reform. However, the ones included in the preceding table are the ones that most likely were in the mind of the institute's policy-makers when they decided to seek a more active collaboration with industry.

On the other hand, it is necessary to clarify expectations or misconceptions that may develop around the desire to implement programs to link IMTA with industry.

First, most likely, income generated from industry and other sources different from the CNA and the federal government, will not be enough to entirely substitute for the financial resources provided to IMTA by these sources. As analyzed in Chapter Three, the prospects for RDO's - Industry interaction in a country like Mexico are small and perhaps for the SHN are even smaller. Therefore, it is necessary to take into account that the chances for IMTA's cooperation with industry may be extremely limited, especially in the early stages of the program. For these reasons, the funds captured from the interaction should be mainly viewed as additional resources to expand the participation of IMTA in the solution of the SHN's problems.

Second, the CNA and SARH still are and most likely will continue to be the principal public organizations within the SHN. For this reason, IMTA should recognize that the main needs, problems and opportunities of the sector will be identified and attended precisely by these organizations and that therefore, the main financial resources of the sector will continue to be channeled through them (including those "earmarked" to support scientific and technological development efforts). Therefore, IMTA should not and is not interested in breaking its ties with these organizations. Its mere intention is to loosen its administrative ties with the CNA because sometimes they represent bureaucratic barriers to the efficient performance of IMTA's responsibilities.

VI.3 Identification of Potential Areas for Linkage

Through the analysis of IMTA's fields of expertise and the industrial sector needs concerning water resources sector it is possible to identify those areas in which a common

interest for the interaction is likely to develop. The principal areas that were identified for the case under study are presented in Table VI.3.1.

Table VI.3.1 Potential Areas of Linkage of IMTA with the Productive Sector

• water quality control
• wastewater treatment
• efficient use of water
• certification of materials and equipment
• numerical and computational modeling
• information services

It is important to point out that the information contained in this table is treated here as fields of expertise and not as services that IMTA may offer and industry demand. However, in the following section, some of these products and services are treated as mechanisms for the interaction between IMTA and industry.

VI.4 Operational Mechanisms for the Interaction

In order to define the main mechanisms for the interaction of IMTA with the industrial sector it is necessary to look beyond the potential areas of linkage and to analyze in more detail the true capabilities of the institute. As these capabilities are the result of the integration of the human, material and financial resources of the institute, their assessment allowed for the identification of the principal capabilities that the institute has developed throughout the years. In turn, this led to the identification of the following mechanisms for interaction as the ones that may have the largest potential for success.

VI.4.1 Contract Research

One of the mechanisms through which the institute has a large potential for interacting with industry is through the establishment of contract research agreements. The institute has proved that it has good capabilities for working in the development of products and processes that industry can use and/or commercialize. This could be the case of technological developments such as: a) technologies for the efficient use of water (e.g. valves, wrenches, sprinklers, plumbing fixtures, etc.); b) meter gauges and electronic comptrollers for the measurement and control of water flow; c) processes and products for wastewater treatment tailor made for the particular needs of different industries; d) technologies for the verification and control of water quality; and e) software for the management of water in manufacturing processes.

VI.4.2 Consulting

As shown by the description presented in Chapter Four, the institute has considerable expertise in most of the technical areas related with water resources including considerable experience in the specific problems of the Mexican SHN. For these reasons, IMTA should consider this expertise as part of its core competencies and therefore it is important to develop adequate means to exploit them efficiently. Undoubtedly the offering of consulting services can be one of such means. After all, consulting is not only one of the most "natural" forms of interaction of RDO's with industry but the institute has also the advantage of having considerable experience in this area, in contrast with some of the other mechanisms for interaction that will be presented here. This is particularly true in the case of the Technical Consulting Group (CT), which has been operating since 1948 and that has accumulated considerable expertise in most of the areas related with hydraulics and other civil engineering fields. For this reason, the group enjoys a considerable prestige not only within the SHN but also in other sectors as well. Besides, as mentioned before, it is expected that demands for services of this sort by firms entering

into the SHN will tend to increase in the following years as a result of the privatization of the sector.

VI.4.3 Training Programs

Taking advantage of the considerable expertise of the institute, of its research personnel and of the facilities of UNAM'S Division of Graduate Studies (DEPFI) located at IMTA, it is possible to develop a link with industry through the offering of training programs. These programs, should be explicitly designed to meet the specific training requirement of industry personnel and could be established in areas such as operation and management of wastewater treatment facilities, monitoring, testing and control of water quality, etc.

VI.4.5 Laboratory Services

One of the mechanisms for interaction that is probably easier to implement is the one related with the provision of specialized laboratory services to industry. This could be the case for example of the execution of physical, chemical and microbiological analyses of water quality. This is an area in which the institute has a good potential for commercialization of its services because many firms and industries cannot afford to invest in the sophisticated technologies and facilities necessary to perform these analyses and that IMTA already has available (e.g. laboratory for water quality control).

VI.4.6 Certification of Materials and Equipment

Following a rationale similar to the case of laboratory services, IMTA has a good potential for the commercialization of services related with the certification of materials and equipment. Thanks to IMTA's expertise in the technical standardization and certification of materials and equipment according to Mexican norms for quality control and to its well equipped testing facilities, the institute has already started testing and

certifying products for private firms. Some of the industries that have contracted these services include manufacturers of pipes, valves, joints, meter-gauges and pumps.

VI.4.7 Information Services

Taking advantage of its facilities, information sources and communication networks with important national and international organizations of the water resources and other sectors, IMTA can offer specialized information-related services to industry. The interaction with industry in this area can be done through the provision of services such as access to data banks, bibliographical searches, direct access to libraries, on-line consulting, etc.

As the experience of the institute with respect to the interaction with industry is extremely incipient at this point, it might not be convenient to promote simultaneously the interaction through all the mechanisms previously described. Rather, it is preferable to start with those mechanisms that are most simple (e.g. consulting, laboratory services, certification of equipment, etc.), and later on to seek a deeper interaction through more complex mechanisms (e.g. contract research). The reasoning behind this suggestion is that through the provision of the former, it is easier not only to initiate the cooperation but also to earn the confidence and trust of industrial customers. In turn, if this is achieved, it may be possible to gradually attract the attention of these customers to some of the other activities of the institute (e.g. R&D) and hopefully, to motivate in them a desire to collaborate with IMTA through other mechanisms.

VI.5 Organizational Arrangements for the Interaction

Having identified the potential areas of linkage and the most appropriate mechanisms for the interaction, it is necessary to design a specific organizational structure to promote, guide, support and manage the interaction. As mentioned before, until now most of

IMTA's activities related with technology development have been handled more or less independently by the different technical coordinations of the institute. Each of them has been making efforts to establish their own contract agreements and to capture income from new sources (for example, through the commercialization of products and services). However, if the institute is to take the effort to promote a more active interaction with industry more seriously, it needs to institutionalize these efforts. In order to do so, it is first necessary to establish the appropriate formal organization arrangements to handle the interaction.

Considering that the possibilities for the successful interaction of IMTA with industry (as well as with other organizations in the private and public sectors) are rather limited at this point, it might be advisable to start by establishing a small office or unit in charge of handling issues related with the management of technology at the institute. This office, from here on termed as Technology Management Unit (TMU) could play a role somewhat similar to that played by industrial liaison programs and technology licensing offices such as those described in Chapter Two. Table VI.5.1 summarizes the main activities that this unit might undertake.

Organizationally, the TMU could initially form part of the coordination of professional development, as this is currently the coordination of IMTA more directly related with other organizations in the SHN as well as with the scientific and technological development of the sector. However, as the activities of the unit start to become more relevant for the institute (e.g. as the number of contracts with industry increase), it would be convenient to place it at a higher hierarchical level to stress the importance of the interaction with other organizations, and in particular, TMU's contribution to technology transfer. Whichever might be the case, it is important to give the unit organizational visibility not only within the institute's industrial customers or partners but also internally

so that other coordinations of IMTA recognize its work and feel attracted to seek collaboration with the unit.

Table VI.5.1 Principal Activities/Roles that Could Be Undertaken by IMTA's Technology Management Unit.

- Provide a visible door through which industry can easily gain access to the institute's expertise
- Promotion of the products and services that IMTA can offer to the industrial sector
- Offering of help to the different coordinations of the institute and its researchers to locate industrial sponsors or potential partners interested in the commercialization of the products and/or processes developed at the institute
- Handling of issues related with the protection of intellectual property from the products, processes and technical documents developed at the institute. This would include issues such as the review of patent disclosures, filing of patent applications, negotiation of copyrights and patent licensing, etc.
- Provision of support and legal advice in the formulation and negotiation of contract research agreements and other types of contracts involving the provision of specialized services such as consulting, laboratory testing, certification of equipment, etc. Similarly, the office could provide support in agreements and contracts involving the transfer of technology from the institute to industry.
- Formulation of institutional policies and regulations to support and handle the interaction with industry. These might include, among others, intellectual property and contract research polices; internal regulations for the generation and distribution of income; and incentive programs for researchers (such as monetary rewards, awards and promotions).

It is important to point out that it may not be convenient to establish this TMU under the premise that it will be the sole office through which all the activities related with issues such as technology transfer or contracting should be channeled. Rather, TMU needs to be envisioned as an office intended to provide support and counseling to the institute's coordinations in the negotiation and establishment of their own contracts with industry.

VI.6 Formulation of Norms and Policies to Support the Interaction

Although the central objective of the establishment of the TMU is to integrate the institute's efforts related with technology management, in order to do so, first it is necessary to formulate clear policies and norms to handle the interaction of the institute with the industrial sector. These policies and regulations are intended to provide a set of guidelines for the management of the interaction as well as to define the basic mentality of the institute regarding this issue.

Although in principle it is logical to assume that all the agreements and contracts negotiated by the different coordinations of the institute will need to comply with these policies and regulations, this does not necessarily mean that they have to be too rigid. On the contrary, the policies should be formulated in such a way as to provide for the flexibility necessary to negotiate each contract on an individual basis in order to take into account peculiarities that may be important in each case.

In the following sections suggestions are made of the most important factors that should be considered for the establishment of each of the main policies and regulations required.

VI.6.1 Intellectual Property and Publication of Results Policies

As mentioned in Chapter Two one of the main barriers for the establishment of fruitful mechanisms for the interaction between RDO's and industry is related to a number of controversies associated with the protection of intellectual property. Typical examples of this sort are disputes over: a) ownership of intellectual property rights (particularly in the case of patents); b) terms and conditions for technology licensing; and
c) publication and confidentiality of results.

Without entering into much detail in the specifics of the policies that the institute needs to formulate to handle intellectual property protection, Table VI.6.1.1 presents a general guideline of recommendations that IMTA may consider. These recommendations basically define the posture that IMTA can adopt towards intellectual property during the negotiation of contracts such as those involving contract research or technology transfer. Therefore, the TMU can have these recommendation in mind while formulating the respective policies.

Table VI.6.1.1 General Recommendations for the Formulation of Intellectual Property Policies to Handle the Interaction of IMTA with the Industrial Sector.

- Maintain property rights of all patents
- Maintain the rights for disclosure of research results
- Deny sponsors' requests for modification of research results
- Establish a copyright policy for software development
- Minimize the use of information of restricted access
- Try to avoid the signature of confidentiality agreements as long as this does not constitute a barrier for the interaction
- Formulate several alternatives for technology licensing (including, license exclusiveness, royalty payments, etc.)

VI.6.2 Contracting Policies

If the institute is to be able to start signing contracts with industry it is first necessary to clearly define policies to regulate those agreements as well as the main principles that should guide such policies. The following are some of the most important provisions to consider. First, it is necessary to define what types of projects and what characteristics should those projects have in order for the institute to accept to carry them out. Some of the factors that may be considered in this case include, intellectual content, relevance for the development of the SHN, congruence with IMTA's missions, etc. It is important to

point out here that in this case it is fundamental to distinguish between those contracts involving research agreements and those related to the provision of services such as consulting, laboratory testing, certification of equipment, etc. The reason is that their intellectual content, relevance, etc. obviously varies according to their specific nature.

Second, specific regulations are needed for the provision of specialized services such as: the time allowed for each researcher to participate in consulting activities; the terms and conditions for using laboratory facilities and equipment (to avoid conflicts regarding priorities in their use); the possibility of entrepreneurs who are also researchers to contract the institute's services, etc.

Third, it is essential to define who should be responsible for the research, performance of tests, etc. (in terms of individuals, teams, coordinations, etc.). This is very important not only for the internal control of the project but also to clearly define formal communication channels with the sponsor.

Fourth, it is important to make clear who has the authority for the technical direction of the project. This is mainly intended to avoid potential conflicts over which organization (IMTA or its industrial partner) has authority for taking decisions involving the technical content of the project.

Fifth, due to the nature of some of the projects performed (particularly research agreements), it is necessary to clearly define what are the responsibilities of IMTA. This is especially important if the results of the project are uncertain. In these cases, it might be convenient for the institute to adopt the position that research will be performed on a best effort basis.

Sixth, for the same reason stated before (considerable uncertainty in some research projects), it is necessary to define the institute's responsibility in terms of delivery of results within a certain time frame. In this sense, it might be convenient to provide for some latitude in terms of compliance with deadlines.

Seventh, it is important to define the terms and conditions for the reimbursement of costs as well as the attitude that the institute is willing to assume with respect to financial risks. This could include, for example: a) responsibility for financial losses; b)the integration of total costs (e.g. percentage to be charged for indirect costs, such as use of libraries, maintenance of physical facilities, etc.); c) terms and conditions for the reimbursement of costs (e.g. time for repayment); d) discretion for shifting funds between different categories within the same project; e) procedures for approval of costs in excess of authorized budgets; f) presentation of expenditure reports to project sponsors, etc.

And finally, it is essential to define the terms and conditions for the termination of the contract. These include the establishment of circumstances for termination, payment of phase-out costs, rights for termination, notification responsibilities, etc.

In order to take into account these issues, it may be advisable for IMTA to formulate standard agreements to regulate its interaction with industry. This is not to say that all the contracts signed at the institute should comply with these standard agreements, but rather they are intended to provide a basis for the negotiation of contracts. Therefore, they should be formulated in such a way as to be flexible enough to provide enough latitude to accommodate the specific requirements of IMTA and/or sponsor for each particular project.

VI.6.3 Income Generation and its Distribution

As the financial resources of IMTA have always come either from the federal government or from the CNA, the institute has never developed clear regulations to handle the generation of income and its distribution. However, IMTA's intention to diversify its funding sources is stressing the need to define clear regulations regarding the management of these funds. Although the establishment of these regulations is not necessarily of the competence of the TMU, it is important to express through this unit the provisions that should be considered in those regulations to facilitate the interaction with industry.

Right now, this issue of income generation and its distribution represents one of the most important barriers that the institute is encountering to capture funds from sources other than the CNA. Overcoming this barrier is currently one of the most important challenges that the institute is facing because this is by no means an easy task. The reason is that the judicial status of the institute (as part of the CNA) does not allow IMTA to capture income from sources other than the federal government or the CNA. From a legal perspective IMTA does not have an independent judicial status and therefore, it is only recognized as part of the CNA. In practice this means that even if the institute is able to negotiate contracts with industry, the payments received from the commercialization of its products and services have to be made to the Treasury of the Federation (of the Ministry of Finance) and not to the institute. Even though later on the Treasury can reimburse these payments to SARH or the CNA there is no way to guarantee that the income generated will ever get back to the institute.

The most obvious way to handle this situation would be to try to obtain the legal status of an independent organization. However, this strategy will definitely encounter considerable opposition from SARH and CNA, which most likely will not be willing to

loose their control over the institute. For this reason IMTA is now considering the alternative of creating an independent foundation, that could capture those resources and later on grant them to the institute in the form of contributions or donations. Although the establishment of this foundation seems to be a feasible alternative to solve the problem, it is important to note that in order to successfully create the foundation it is still necessary to earn the support of top level officials. In particular, the political support of SARH's Secretary will be once more fundamental for implementing the reform.

On the other hand, the clear definition, implementation and diffusion of policies and regulations for the generation and allocation of funds across IMTA's entire organization is important because of several reasons. First it is vital that researchers be aware of the benefits that the interaction with industry can bring to them. If researchers fail to recognize the importance of these benefits or if the institute fails to communicate those benefits to them, the incentives will not work as desired and the overall productivity of IMTA may not be sufficiently enhanced. And second, it is also extremely important that there is certainty among the different coordinations and research groups of the institute of the benefits that the same interaction will bring to each unit. This is important because there may be some groups more actively engaged in the interaction and its members may feel that it is unfair, for example, if resources generated by them are allocated to other research groups.

Some of the main points that these regulations need to include should be: a) distribution of income generated by a particular interaction within IMTA and its different coordinations (e.g. the percentages granted to IMTA, to the particular coordination managing the project, to the specific unit in charge of developing such project and finally, to the researchers or other personnel involved in it); b) the discretion granted to

coordinations and research groups for the use of the new funds; c) the amounts and timing for the allocation of funds, etc.

VI.6.4 Evaluation Programs, Incentives, Rewards and Promotions

The first step required to establish successful incentive and promotional programs in an institution like IMTA is necessarily to design adequate systems to evaluate the performance of coordinations, teams and individuals participating in any project involving some kind of interaction with industry. It is frequent to observe how many RDO's base their evaluation schemes in systems such as those involving "peer review" or the number of articles that researchers publish in technical journals per year (and, in particular, in terms of those published in magazines of international distribution). However, this approach may not be appropriate for the evaluation of researchers working in technological developments derived from contracts with industry (Waissbluth, 1990). The reason is that quite often this technological developments are too specific and of little interest to leading journals. Therefore, other factors need to be incorporated into the evaluation schemes. This could be the case, for example, of patent applications and patents obtained. However, it is important to consider this issue carefully because a patent does not guarantee the successful commercialization of an invention nor the quality of the work performed. Perhaps a more adequate alternative would be to try to evaluate the performance of researchers based on the relevance, creativity and quality of their work. The problem is that in order to do this it is necessary to rely again on the "peer review" process; but anyway, the mere fact of explicitly considering this issue in the evaluation is much better than considering only the number of publications.

An evaluation system makes it possible to design incentives to: a) earn support and build in participation (especially from researchers) for the establishment of programs to interact with industry; and b) enhance the creativity, willingness to innovate and productivity of

the institute's personnel. As mentioned in Chapter Two, the mere interaction with industry can motivate researchers in several ways. First, because it represents a chance for enhancing their own knowledge and to keep them abreast of technological progress; second, because it gives them a chance to contribute to the real satisfaction of society's needs and to break down the negative opinion that industry has of RDO's researchers; third, because it allows them to increase their professional prestige; and finally, because it represents a chance to increase their personal income.

Although all these motivations might be powerful reasons for researchers to support and actively participate in RDO's - Industry interaction programs, it is still necessary to design specific incentives to motivate this cooperation even more. Especially important in the case of countries like Mexico and institutions like IMTA are the monetary incentives given to researchers. The reason for this situation is that their wages are relatively low (particularly as compared with researchers working at developed countries). To solve in part this situation, IMTA currently grants several bonuses to its researchers throughout the year. However, in reality these bonuses constitute part of their base salary and therefore, they do not represent any additional income for them. Some researchers have found a way to compensate for this condition through their admission into the National Researchers System (SNI) as this admission means they are eligible for receiving an additional payment from the federal government. However, the admission to the SNI is not easy (only 27 of the 269 researchers from the institute form part of the system) and therefore, many of the institute's employees are still underpaid.

As mentioned before IMTA's decision to pursue a strategy that stresses the need for a more active collaboration with the industrial sector was largely the result of solving precisely this condition. However, even if the institute succeeds in the establishment of interaction programs, there are still some problems that must be solved regarding the

provision of monetary incentives to researchers. For example, in contrast with what happens in other countries (e.g. the U.S.), in Mexico, the Federal Working Law (LFT) forbids public employees to receive work compensations in addition to their own wages (as wages are considered to compensate entirely for their work). In practice this means that IMTA's researchers are not eligible for receiving a share of the royalties captured by the institute even if they were derived from the licensing of an innovation developed by them. Similarly, researchers cannot obtain earnings derived from the commercialization of software, articles or books performed by the researchers during their normal working hours at the institute. According to the LFT, all of these innovations, books, etc., and the income derived from their commercialization belongs entirely to IMTA and therefore the institute does not have any responsibility to share earnings derived from them with its researchers.

In order to handle this situation, the institute is considering once more the possibility of creating an independent foundation. As mentioned before, the foundation may attract funds from industry and later on transfer those funds to the institute as donations. Because of their nature, the foundation would be able to "earmark" these donations and assign them to particular researchers in the form of awards, prizes, etc.

With respect to promotional systems the most important aspect to have in mind is that it is necessary to clearly define how these systems work. This can significantly help to reduce the expectations and uncertainties that frequently surround RDO's working environments. In this way, individuals can make their own estimates of their real chances for their promotion and react accordingly (hopefully motivated by their aspirations to occupy higher posts). However, it is important to point out that in a bureaucratic organization like IMTA, in which many researchers and/or managers are

directly appointed by top level officials, this uncertainty really will never be completely eliminated.

VI.7 Staffing the Programs for the Interaction

There seems to be a generalized agreement among researchers studying the phenomena of RDO's - Industry interaction that some of the most critical success factors for the establishment of programs to link the two types of organizations are related to the performance and attitudes of the individuals involved in the interaction (Solleiro, 1990). Therefore, IMTA should place special attention in the selection of the personnel from each coordination, team, etc., that will interact with industry and also from those that will work at the TMU.

Much has been written about the importance of functional roles (e.g. gatekeeper, idea generators, project sponsors, champions, etc.) to enhance the overall performance of RDO's.[74] However, at the initial stages of the interaction program, the selection of technology managers (TM's) to staff the TMU is particularly relevant. The reason for this assertion is that these individuals normally are the vital links between the RDO's and industry because they often work as translators among the different parts involved in the interaction.[75] In a way, their job is intended to reduce the ideological, social and cultural differences that naturally exist among individuals working at each of these sectors in order to facilitate communications among them. The role of TM's may be especially critical if the individuals involved in the interaction have different professional backgrounds (e.g. managers vs. engineers) as this condition normally complicates communications even more. For these reasons it is convenient that these individuals are

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74 Roberts, E. & Fusfeld, A., (1982), "Critical Functions: Needed Roles in the Innovation Process", in Career Issues in Human Resources Management, R. Katz (Editor), Harper Business, New York, New York, U.S., pp. 182-207

75 Díaz, R., (1992), "Recursos para el Desarrollo Tecnológico. El Caso de la Comunidad Emergente de Gestores de Tecnología", in Política Científica e Innovación Tecnológica en México, Campos y Medina (editors), IIMASS-UNAM, Mexico City, Mexico, pp. 117-139

characterized for being proactive leaders, effective communicators and also for having skills in a variety of fields of expertise (engineering, management, economics, etc.) so that they are well prepared to understand, assimilate, translate and communicate information among the parties involved in the interaction.

VI.8 Formal and Informal Communication Networks

The importance of communication networks for a successful interaction between RDO's and industry has been continuously stressed throughout this work. Broadly speaking, these networks can be characterized as consisting of two types of communication channels: formal and informal. Most of the processing and exchange of information relevant to the interaction precisely takes places through these channels.

Formal communication channels are the direct result of organizational structures. Therefore, the specific organizational arrangements set in place by the institute to manage the interaction, as well as the existing power relationships and lines of authority will determine the general configuration of the formal information network.

In contrast, informal communication channels tend to develop more or less spontaneously, with no managerial intervention.[76] However, the relevance of informal communications for the interaction process and, in general, for the efficient flow of information stresses the need for management to set an appropriate stage for their development. This could be the case of the organization of seminars, conferences, workshops, etc. with the participation of personnel from the institute and industry in order to set up a convenient stage for people to get acquainted with each other.

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[76] Allen, T.J., (October, 1970), op. cit.

Because the interaction itself requires a great deal of information flow, the direct personal contact within and between RDO's and industry is a valuable communication channel. After all, verbal communication permits timely information exchange, rapid feedback and critical evaluation, as well as the opportunity for real-time recording and synthesis of information.[77] Similarly, verbal communication reduces the possibilities of misunderstandings, misinterpretations and confusion as it makes the flow of information more effective.

On the other hand, the establishment of specific communication networks should be contingent on the nature of the task, on the nature of the task environment and on the degree of interdependence of the task with others (Tushman, 1979). This means that the patterns of communication should be different according to all these aspects. Therefore, the communication channels established by IMTA to promote the interaction through mechanisms such as the provision of technical services (e.g. laboratory testing or certification of equipment) should be different from those related for example, with consulting or contract research. In practice what this means is that it is not always convenient to promote the direct interaction between all the individuals involved in the interaction. When the interaction consists of mechanisms such as contract research, it may be convenient to promote direct communication between researchers from IMTA and technical expertise from industry; but when this interaction involves routine services such as laboratory testing, the interaction can probably be more effective if it is done through a laboratory supervisor rather than through the person directly performing the test. The use of individuals such as supervisors (often referred to as "boundary spanning individuals") is especially important when there are differences in the language and technical orientation of the individuals participating in the interaction. Therefore, in this

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[77] Tushman, M.L., (Winter, 1979), "Managing Communication Networks in R&D Laboratories", in Sloan Management Review, Sloan Management Review Association, Alfred P. Sloan School of Management, MIT, Cambridge, Massachusetts, U.S., pp. 37-49

sense, these "boundary spanning individuals" play a role of "translators", similar to that of the professionals that will need to work at the TMU.

Finally it is important to mention that both networks have to be flexible enough to adapt to the different information processing demands of the various mechanisms used for the interaction as well as to the dynamic nature of these mechanisms and their particular information requirements.

Chapter Seven: Conclusions and Recommendations

Throughout the previous chapters this work has presented an overview of the problems associated with the interaction between RDO's and industry placing particular emphasis on the principal factors motivating or inhibiting the collaboration. The analysis of the experiences of several institutions and countries was certainly very valuable not only for pointing out these factors but most importantly for providing useful insights on possible alternatives to overcome most of the problems related with the interaction.

Certainly, there are many conclusions that can be drawn from this work including important aspects related to each of the three levels of analysis presented here: structural, institutional and individual. Similarly, there are many recommendations that can be made to RDO's, industry and governments so that they can set the basis and take appropriate steps to foster the development of fruitful relations between RDO's and industry. However, as the ultimate purpose of this work is to analyze the situation of a particular RDO and to apply the results of that analysis to design a strategy to link this organization with the industrial sector, most of the conclusions and recommendations presented here refer to the specific case of IMTA.

Although it is obvious that this characteristic significantly constraints the applicability of the observations made here, it is important to note that many of the constraints and opportunities found in this case may also be encountered by other RDO's and industries trying to establish somewhat similar programs. Obviously this does not mean that the experiences of IMTA can be readily extrapolated to these cases. However, they certainly can provide valuable insights for other institutions facing similar problems.

On the other hand, it is important to recognize that due to the nature of the institutions involved in this case, most of the comments presented here are based on considerations of institutional and individual factors rather than on the structural conditions affecting the interaction. This should be easy to understand because it has to be remembered that these conditions are mostly external to RDO's and therefore these organizations have almost nil influence or control over them.

According to these rationale, the following recommendations can be made:

- The objectives of the policies and programs related with the interaction of the institute with industry have to be clearly defined and communicated: a) externally, to powerful actors that might have some kind of influence over the institute (e.g. CNA and SARH); and internally, to IMTA's personnel across the entire organization. This has to be done before the policies and programs are actually implemented in order to reduce the possibilities of misunderstandings and misinterpretations; to clear out confusion; and in particular, to reduce uncertainties which may create among researchers the perception of an unstable working environment and therefore, possibly giving rise to opposition to their implementation. Similarly, a clear definition and communication of goals will prevent the formation of false expectations and myths around the interaction. This consideration can also be very important because if these expectations are not satisfied by the results of the interaction programs, they can be very damaging both for the institute and for its personnel. Not only can this situation diminish the real value of the interaction in front of the eyes of people inside and outside the institute but it also has the potential for affecting the prestige and reputation of researchers and the institute itself.

- The implementation of actions and programs to link the institute with industry needs to be done gradually. Initially, simple mechanisms and organizational arrangements for the interaction may be used. Later on, as experienced is gained and as the work load increases, more complex mechanisms can be used (e.g. R&D consortia or spin-offs) and organizational arrangements (e.g. technology transfer centers) can be set in place. Whichever may be the case it is absolutely essential for IMTA to provide enough visibility to both programs and organizational arrangements, inside and outside the institute. This will not only help promote the capabilities of the institute and therefore the interaction itself, but it will also provide certain hierarchy to the interaction programs and this is an issue that may be particularly critical to insure internal compliance.

- The formulation, implementation and wide diffusion of policies and regulations supporting the interaction is also indispensable. This could be the case of those related to: intellectual property protection, generation of income, distribution of earnings, evaluation of personnel, provision of incentives and rewards and those concerning promotional systems, among others. The relevance of these actions is that they are essential to: a) raise the awareness of personnel from the institute of the constraints and opportunities provided by these policies; b) reduce the uncertainties regarding the costs and benefits that particular researchers, coordinations, etc., can derive from the interaction therefore allowing them to make more informed decisions; and c) provide the basic guidelines to handle the interaction with industry as well as to let the institute's personnel know the main position of IMTA regarding this issue.

- The staffing of the programs designed to link the institute with industry is an issue in which IMTA's management has to place especial attention. As discussed before, it is desirable that those individuals directly involved in the interaction fulfill particular

requirements in terms of their qualifications (e.g. technical expertise, good communication skills, proactive leadership, etc.). After all, the human factor is a vital element of the interaction because most of the barriers frequently encountered are precisely related to differences in the attitudes and perceptions of the individuals involved in such interaction. In this sense, it is absolutely essential to staff the programs with professionals: a) capable of handling efficiently the conflicts that might arise during the interaction; b) with the ability to listen, assimilate, translate and communicate information of different natures between both parties; and c) firmly committed to overcome the multiple barriers that will be encountered during the implementation of the programs.

- Because of the nature of the interaction process, the institute will need to take appropriate steps to insure the development of good communications among the parties involved in the interaction. This will require on the one hand, the establishment of formal communication channels to ease the flow of information inside and outside the organization; and on the other, the provision of proper working conditions to foster the emergence of personal relationships and informal communication channels.

- It is advisable that when the institute is working in the design of its strategy for interacting with industry, they do so considering "flexibility" as one of the main premises of such strategy. As mentioned before, this is absolutely essential to eliminate unnecessary barriers (such as extensive bureaucratic procedures) and also to provide enough room to accommodate particular needs from both parties or otherwise, the interaction may be inhibited.

- Due to the complexity inherent in the establishment of programs to link RDO's with industry; the difficult structural conditions that the SHN and Mexico are currently experiencing; the difficulties associated with the juridical status of the institute and with its integration into the SHN; the limited demand that may be expected for its products and services (at least initially); and the lack of experience of the institute in the interaction with industry, it is important to recognize that the possibilities of the institute to interact with industry are limited, at least in the short term. For this reason, IMTA should expect to obtain small benefits from these programs in their initial face. However, this does not necessarily have to be discouraging because their implementation costs will also tend to be small.

- It seems that the interaction with industry can be a valuable means for the institute to generate additional resources, to diversify its funding sources and to reduce to some degree its financial dependence on the CNA and the federal government. Similarly, it can be helpful to provide monetary resources to grant incentives to the institute's researchers in order to motivate their creativity and their desire to innovate. However, the establishment of these programs should be mainly viewed as a mid or long-term effort rather than as a short-term commitment. Under these premises, the establishment of programs to link the institute with the productive sector should be viewed as intended to set the basis for its sustainable development, but in a way more congruent with the real demands of the different sectors of the SHN.

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